MACHINERY

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A SCHOOL THAT TRAINS BOYS FOR SHOP WORK*

SHOP AND DRAFTING-ROOM METHODS OF A PROGRESSIVE TECHNICAL HIGH SCHOOL

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ONE of the most serious defects of the departmental method of factory administration is that it trains boys to be machine operators instead of mechanics. As this method enables a boy to obtain employment operating a milling machine, drill press or other tool—and to receive fairly good wages for doing so—he naturally hesitates to sign a contract for four years' apprenticeship, during which time he will be working at a nominal rate of pay. The result is that there is a scarcity of mechanics who have a knowledge of all of the branches of their trade. The importance which machinery builders attach to this condition is emphasized by the fact that nearly every convention of such organizations as the National Machine Tool Builders Association and the National Metal Trades Association, brings forth discussions of ways and means of training boys so that they may develop into competent mechanics.

In such towns as Cincinnati, Ohio, where there are a large number of machinery building establishments, it is probable that the "part time" plan, where the boy spends one week in school and the next in the employ of a machinery building factory, offers the best solution of this problem which has yet been advanced. Such a plan is only feasible, however, where there are a sufficient number of factories adjacent to the school to make it possible to find shop work for the boys during the alternate weeks. Consequently, this is only a partial solution of the problem. It is felt that the method described in this article will be of interest to readers of MACHINERY, in that it is a plan which seems to possess more than the ordinary merit of systems of industrial education.

The William L. Dickinson High School was built in Jersey City, N. J., in 1905, and like the majority of such institutions, it had two purposes in view. One of these was to fit boys and girls for entrance into college, and the other to provide a general course of education for students who intended entering upon their life's work after completing the high school course. The work of the average high school course is generally recognized to be of little direct value to the boy who intends entering shop work. His training in mathematics and science may be of value to him, but only after he has passed through the preliminary period of his training in the shop.

For the purpose of providing a more practical form of education for this class of students, the technical and industrial department of the William L. Dickinson High School was established in 1912. This department is under the direction of Mr. Frank E. Mathewson, who has had a wide experience in shop work, and in the education of boys for shop work in several of the leading technical high schools of the country. Two courses of study are offered in the mechanical department. The first is a two-year course, which aims to give boys training in shop work, mechanical drawing, mathematics and applied science. The second is a four-year course. In the latter course, the first two years are devoted to training in mathematics, drawing and shop work. During the last two years, the students are allowed to specialize in the work which they intend to follow after leaving school.

The chief distinction between the equipment and work done in this school and that carried on in other manual training schools is that the conditions under which the boys work are as nearly as possible those which exist in modern manufacturing plants. All of the equipment consists of full-size machines which are capable of doing work on a manufacturing scale, and this equipment has been carefully laid out in the way it would be in a regular factory. Particular care is also taken on the part of the instructors to train the boys to use their tools as they will be required to do when working

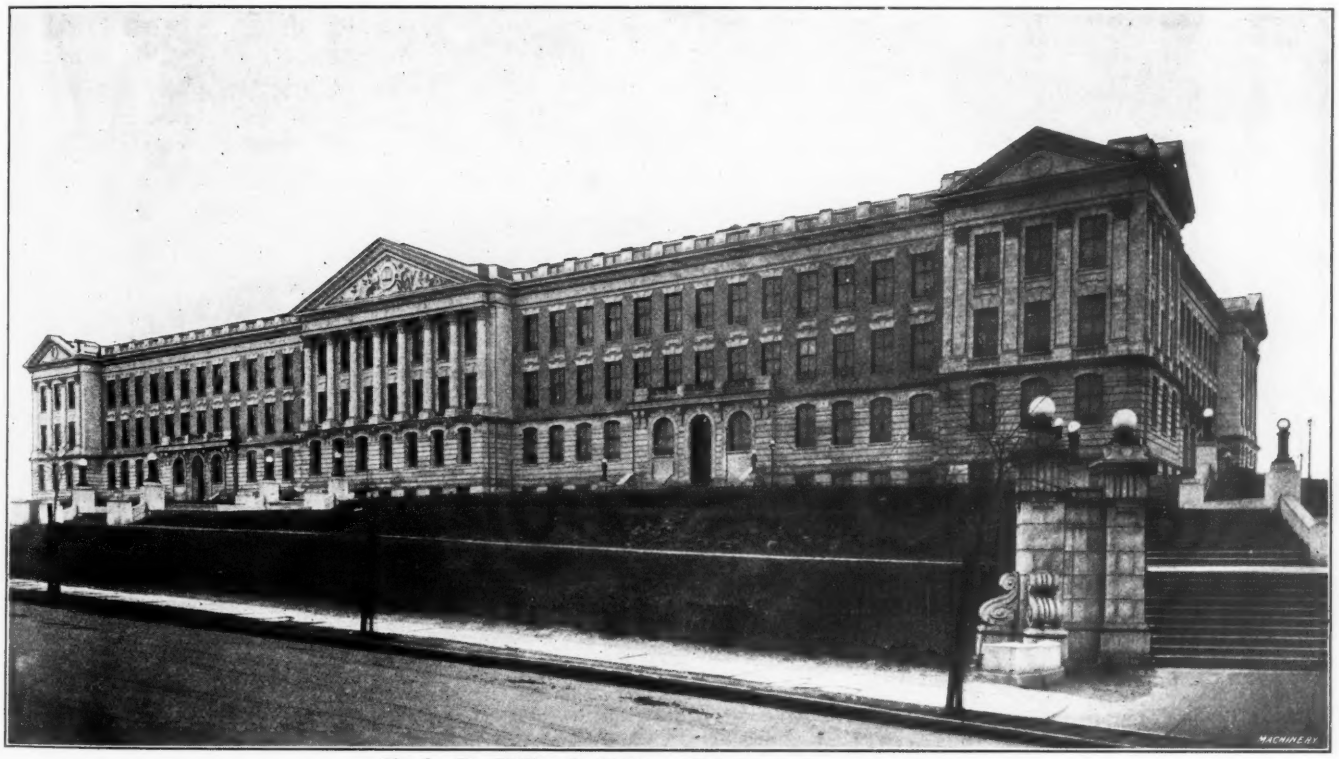

Fig. 1. The William L. Dickinson High School, Jersey City, N. J.

* For other articles on industrial education previously published in MACHINERY, see "State Trade School of Bridgeport," October, 1912, engineering edition; "Features of Apprenticeship System at the G. E. Co.'s Lynn Works," April, 1912, engineering edition; "The Cincinnati Method of Industrial Education—A Friendly Criticism," March, 1912, engineering edition; "The Wentworth Institute," October, 1911; "Training of Machinists in the Trade School," July, 1911, engineering edition; "The Development of Machinist Apprentices," October, 1910, engineering edition, and other articles there referred to. See also other articles dealing with this subject in the present number.

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in a factory. Modern factory methods of management are also followed as closely as possible. The result is that the boys are familiar with factory routine before leaving school, and although there has not been sufficient time for a class to complete the prescribed course of study, it is felt that this training will enable the graduates to grasp the routine methods of a factory much more rapidly than would otherwise be possible.

The distinctive feature of the shop work which is being done in this technical high school is that it consists of actual machine parts. Two important advantages are secured

Fig. 2. View of One of the Drafting-rooms of the High School

from the selection of such classes of work. First, they constitute the kind of work which the boys will be called upon to handle when they leave the school and go to work in a factory; and second, more care and interest will be taken when the work is to find some practical application. In this connection it may be mentioned that the students are at present working upon the construction of thirty speed lathes which are to be used in the vocational schools of Jersey City. The drawings for these lathes were obtained from a machine tool builder, and as the parts are comparatively simple, they afford excellent subjects to be handled in the pattern shop. When the patterns are made they are transferred to the foundry, where the castings are made, and these, in turn, go on to the machine shop and assembling shop. This is but one example, but it will serve to show the class of work which is being handled. The intention is to have the more advanced students handle such work as building small steam engines and similar units, when they have progressed far enough to be able to do this satisfactorily.

In laying out the work for the different drafting-room and shop courses, an effort has been made to interlock these departments as closely as possible. This article has particular reference to the methods followed in the machine shop. However, the work of the drawing-room, pattern shop, forge shop and foundry are all supplementary to the work of the machine shop, and the methods followed in these departments will be briefly outlined in order to lead up to the work done in the machine shop.

Drafting-room

The most important feature of the work of the drafting-room is the way in which its relation to the work of the pattern shop and machine shop is emphasized. After the boys have been given sufficient training to familiarize them with the use of drawing instruments and methods of mechanical drawing, the work assumes a practical nature. Two opportunities for working out this feature are afforded. The first consists of making drawings from which patterns are made in the pattern shop and pieces finished in the machine shop. The second is sending the boys down to the different shops to make free-hand sketches of parts which are being handled in those departments, and then having them come back to the drafting-room and make complete working drawings from these sketches. It will be obvious that this is the sort of work which the regular draftsman is called upon to handle. The boys are not only required to do this work neatly and accurately, but their ranking is also based upon the length of time which they require to make a complete drawing. If it is necessary for any of the boys to go back to the shop for additional information, after the first trip has been made for the purpose of making a free-hand sketch, the fact is taken into consideration and their ranking is correspondingly reduced.

Pattern Shop

The pattern shop is equipped with standard pattern making lathes made by the American Wood Working Machinery Co., and the necessary equipment of band saws, circular saws, trimmers, and other machines required for performing operations on rough stock. Most of the work in the pattern shop is done from drawings which the students have made in the different drawing-room courses. The idea of this is to give them a clear understanding of the relation existing between the drafting-room and the shop, and to cause them to acquire interest in the work. The patterns made in this shop are sent on to the foundry, where castings are made from them by the same students who have taken part in making the patterns. This is of particular value in giving the boys a thorough understanding of the reasons for the different principles of pattern making. By using the same patterns in the foundry, the students see just why the parting lines were arranged in a certain way, why fillets are necessary and the reasons for the other principles they have followed in the pattern shop.

Foundry and Forge Shop

The foundry is arranged for both floor and bench molding and is equipped with a Whiting No. 1 cupola furnace. A mezzanine floor is on two sides of the room; the charging door of

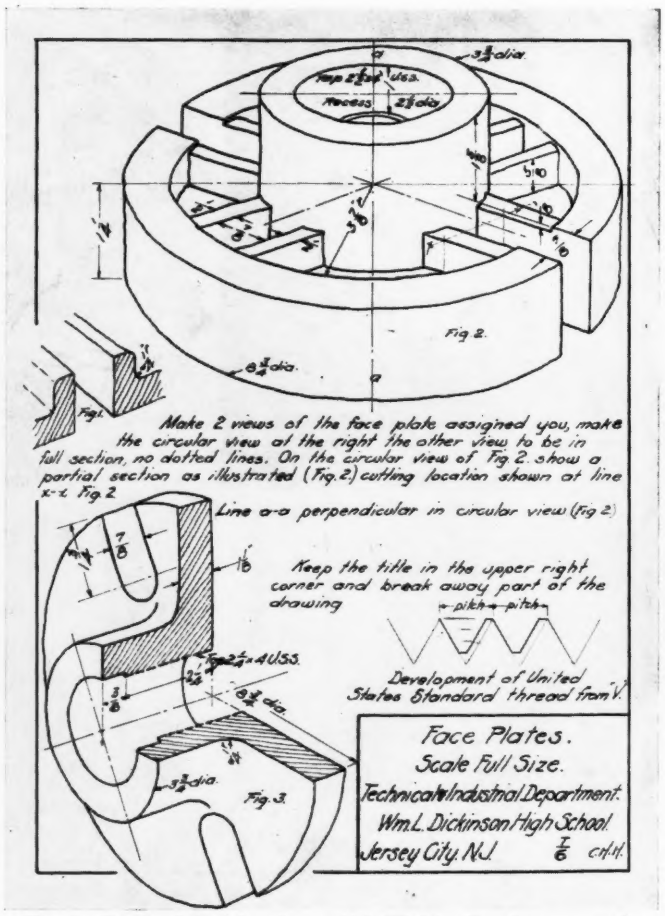


Fig 2.
Fig 1.
Make 2 views of the face plate assigned you, make the circular view at the right the other view to be in full section, no dotted lines. On the circular view of Fig 2. show a partial section as illustrated (Fig 2) cutting location shown at line x-x Fig 2
Line a-a perpendicular in circular view (Fig 2)
Keep the title in the upper right corner and break away part of the drawing
Development of United States Standard thread from V.
Fig 3.
Face Plates.
Scale Full Size.
Technical Industrial Department.
Wm L. Dickinson High School.
Jersey City, N.J.

Fig. 3. Free-hand Sketches from which Working Drawings are made

the cupola is located on this floor and the remaining space is taken up by core-making benches, etc. The brass furnace is also located on the mezzanine floor and a jib crane is provided for swinging the crucibles down to the main floor ready for pouring. The space for floor molding occupies the middle of the room and the benches for bench molding are arranged around three sides.

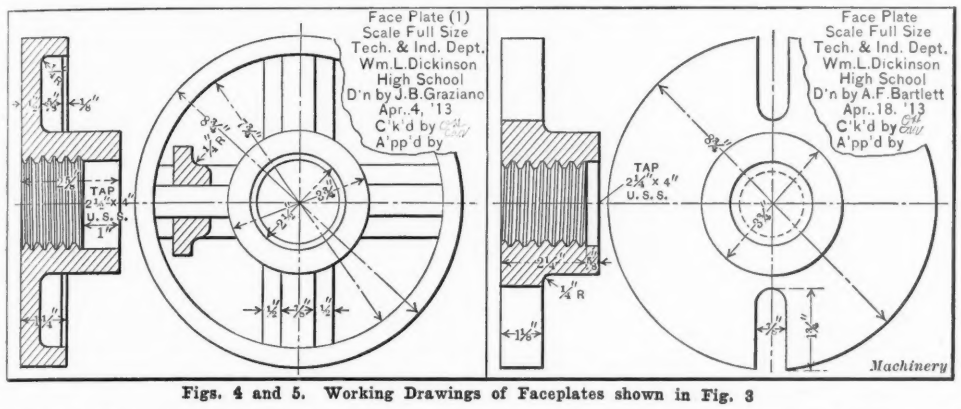
It has been the policy, as far as possible, to have the students make such parts of the equipment as they could handle satisfactorily. In the foundry, the bases for the molding benches

were purchased, while the wooden tops of the benches were made in the wood-working shop. Similarly, the iron brackets supporting the small shelves that carry the molding tools were made in the forge shop, and the wooden tops for these shelves were made in the wood-working shop. The equipment which has been provided in the foundry is believed to be sufficient to produce all the castings which can be handled in the machine shop.

The forge shop occupies a room adjacent to the machine shop and is arranged with the usual equipment of forges and anvils for handling smaller classes of work.

Machine Shop

A review of the usual methods of instruction in the machine shops of different manual training and technical schools has shown that the first work handled consists of such operations as hand filing and chipping. This may constitute good practice



Figs. 4 and 5. Working Drawings of Faceplates shown in Fig. 3

but the pieces upon which the boys are put to work would never be handled in this way in a factory. It was felt that many boys are discouraged by being put through these "paces" before being allowed to start machine operations, particularly when they see the facility with which the work that they are doing by hand can be performed on a shaper or milling machine. In the machine shop of the technical high school, this method of instruction has been departed from in many essentials. In the first place, the boys are put to work on the machine as soon as they come into the shop. The preliminary instruction consists of a complete explanation of the design and construction of the lathes upon which the first work is done. Thus the principles of back-gearing, gearing a lathe for cutting different screw pitches, the method by which the machine is lubricated and kindred subjects are explained. As a result, the boys have a fairly accurate conception of the "why and wherefore" of the operations which they are performing when they start work.

The first actual experience on the machine consists of oiling and cleaning, after which simple exercises in turning, screw cutting, etc., are taken up and the individual students are allowed to progress as their proficiency warrants. In going through the shop it is evident that not only is the standard of accuracy high, but the methods in use correspond closely with those of the regular machine shop. During a recent visit which the writer made to the school, he stopped in front of one of the lathes upon which a little red-haired fellow had just finished turning a mandrel. The working drawing showing the required dimensions was tacked up on the wall before him, and upon asking how close his work came to the required dimensions, this young mechanic slipped his third finger through the frame of his micrometer and adjusted it to the work in the most approved fashion. He then handed the micrometer over with a smile which indicated that he was thoroughly satisfied that its reading would agree with that called for on the drawing.

Contrast of School and Apprenticeship Training

Whenever a new kind of work is taken up, the class is assembled in the lecture room at the corner of the shop and all of the operations connected with it are explained. After this explanation has been given by the instructor, he distributes a set of mimeograph forms which give a general outline of the ground covered in his lecture. This constitutes the second opportunity the boys have to gain the necessary information, and if anyone is still in doubt about certain points, he is at liberty to apply to the instructor for additional information.

Now let us trace the relationship between this sort of training and that which the average apprentices receive in a factory. In the latter case, the boys usually sign a contract for four years work and it may be safely said that very little progress is made during the first two or three years. A large part of the time is taken up in doing inferior classes of work such as cleaning machines, oiling lineshafts and running errands. When the boy is given an opportunity to run a machine, it is set up for him and he merely has to put successive pieces of work in place and start it. The foreman of the average shop is too busy to spend time explaining mechanical

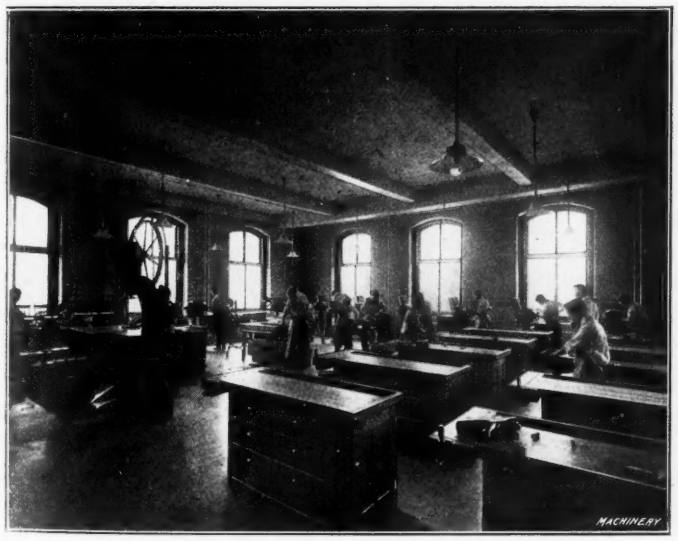


Fig. 6. One Corner of the Pattern Making Shop

Fig. 7. High School Boys at Work in the Foundry

principles or operating methods to the apprentices, so that the boys have to "dig out" such information for themselves or pick it up little by little from obliging men in the shop who are willing to help them along. The boys in the high school, on the contrary, have all of the processes connected with their work explained to them, so that they have a firm foundation for the more advanced work that they will come to in later years of their school course and when they get out into factory work.

A good example of the difficulties encountered by the average apprentice is illustrated by a story which was recently told one of the instructors in the machine shop by a night school student. This boy showed more than usual aptitude in the manner in which he handled lathe operations and be-

came so efficient that the instructor asked him what class of work he was engaged in during the day. The boy answered that he ran a lathe. The instructor then asked him what benefit he expected to derive from devoting his time to work in the lathe department of the machine shop, when he already possessed sufficient knowledge of such work. The answer was that the explanation of the basic principles of lathe work given in connection with the shop instruction made it well worth his while to attend the night school. He then went on to explain to the instructor that his requests for explanations of such matters in the shop had led to his becoming sort of a "fag," the different mechanics trading off information in return for having their tools cleaned, having errands run and for other services of a similar nature.

Management of the High School Shop

The work is issued to the school shops on orders, in the same way that it would in a manufacturing establishment. Each order has an order number, etc., and a careful account is kept of the amount of time which the boy spends upon it. He

Fig. 8. The Forge Shop—Everybody is Busy

is not only required to do a good job, as regards finish and accuracy, but he must also finish his work in a reasonable time. The marks given on each job are dependent on these three factors, and it is quite possible for the boy who takes the greatest length of time to secure the highest mark, as those who rush through their work with haste are likely to produce work deficient in accuracy and finish. The time taken on each job is recorded by one of the students who acts in the capacity of time-keeper, and another student serves as the

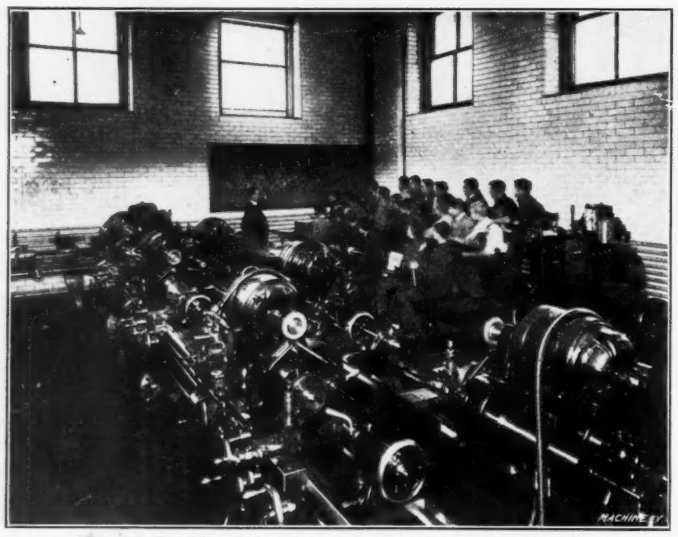


Fig. 9. Teaching Principles of Gearing in the Machine Shop

shop foreman. This boy is given power to issue orders in the shop and the other boys are expected to follow his instructions. This practice is followed to develop executive ability in boys who show any capacity in that direction.

All of the boys at present enrolled in the machine shop are first-year students and are engaged on such operations as turning, facing, centering, screw cutting, etc. Most of the pieces upon which they are working are parts of the thirty speed lathes for the vocational schools, referred to in a preceding paragraph. In machining these parts it was deemed advisable to finish them 1/16 inch over size, in order to avoid the loss of material that might result from inaccurate work. The boys are not told, however, that such is the case, and they

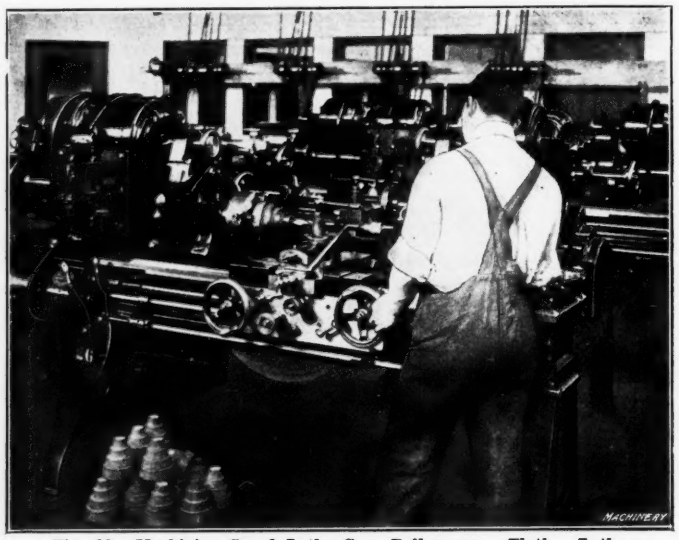


Fig. 10. Machining Speed Lathe Cone Pulleys on a Flather Lathe

think that they are machining the work to the finish dimensions. The boys naturally take more pride in turning out good jobs when they feel that they are doing some useful work, than if they know that the product of their labor will be sent back to the cupola to be remelted and made into another rough casting, upon which the same useless expenditure of work is to take place.

The equipment of the shop in which the first-year students are employed consists of thirty fourteen-inch Flather engine lathes driven by direct-connected motors. There are also four Rivett bench lathes, one B. & S. miller, one American shaper,

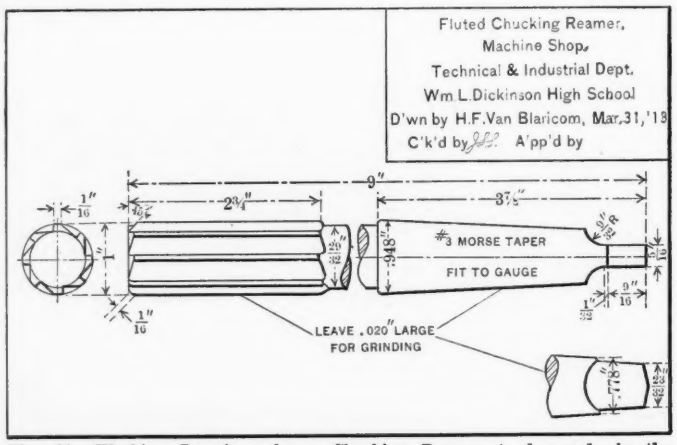


Fig. 11. Working Drawing for a Chucking Reamer to be made in the Machine Shop

one J. E. Snyder drill, one Henry & Wright drill and the necessary tool grinders, centering machines, hacksaws, etc., for handling the classes of work for which such machines are required. A well supplied tool-room has also been provided, which contains an exceptionally complete equipment of tools suitable for the work handled in this shop.

The more advanced students will handle such work as fitting, assembling and other classes of machine shop work for which a higher degree of skill is required. The shop which has been equipped for this purpose contains a complete assortment of tools adapted for such classes of work. These include a Cincinnati surface grinder, Cincinnati and Brown & Sharpe milling machines, Whitcomb-Blaisdell planers, and a complete equipment of the American Gas Furnace Co.'s furnaces for the heat-treatment of tools. This shop is also provided with an excellent tool-room equipment, which has been carefully selected to meet the requirements of the work which will be handled in this shop.

A particularly valuable feature of the work of the technical and industrial department of the Dickinson High School lies

in helping each student to decide what trade he is best suited for. At intervals of six months, each instructor sends in a report of every student in his class. Special forms are provided for this purpose on which the instructor reports not only the quality of work that the boy has done, but any particular ability that he has shown in a given direction. At the end of the first two years it is proposed to hold a conference between the student, his parents and the director of the technical and industrial department. At this conference, the work done by the boy during the past two years will be discussed and the ability he has shown in any given direction will be pointed out

Fig. 12. Upright Drill, Bench Lathes, Centering Machine and Arbor Press

to him. Of course, the ultimate selection of his trade will be left to the boy, but he will be recommended to enter the trade for which the instructors believe he shows the greatest aptitude. As previously stated, his last two years in school will be devoted largely to shop work, special class room work being given in different subjects that are allied to the trades that are taught. After completing such a course of training, it appears evident that a boy should be much more competent to take up the routine of factory work than he would be after completing an ordinary high school or manual training school course. There has not been sufficient time to graduate a class from the

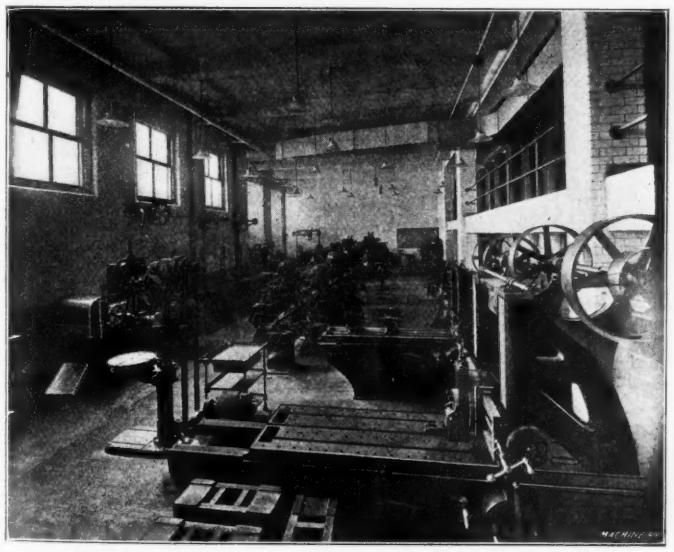


Fig. 13. General View in Shop for Advanced Machine Work

technical and industrial department of this school, so that experience has not shown just how the ability of the boys will compare with that of apprentices who have been trained in a factory by following the usual routine. It appears evident, however, that at the completion of such a course of training, a boy should be able to enter upon his factory work as an advanced apprentice, and that he ought to have a much more specific knowledge of the underlying principles of his trade than he could possibly obtain by the usual methods of apprenticeship.

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Of 4234 known causes of fire in Chicago during 1911, 1121 were due to carelessness in the use of matches.

PROGRESS IN AEROPLANE DESIGN AND AERONAUTICAL MOTORS*

One of the first impressions of the aeronautical show at Olympia, London, early this year, was that the aeroplanes exhibited were workmanlike machines which could be trusted to fly. The show was confined to English and French machines, and neither the United States, Germany nor Austria were represented. A study of the aeroplanes exhibited left one with the conclusion that the greatest part of recent progress in flying machines is due to improvements of the engine. No matter what improvements are made in wing and propeller construction, without a light, powerful and reliable engine these improvements come to naught. Three years ago, there were practically no engines on the market which could be relied on to produce more than forty brake horsepower with a moderate weight per horsepower. At the present time, engines giving 100 to 150 brake horsepower are often used in aeroplanes, and there are some makes of engines available at even greater powers.

The improvement in the engines, however, has not been accompanied by any radical alteration in their general outlines. All the types now in use were developed several years ago, and the improvements have been in detail and in better proportions of the parts, as well as in the kinds of materials used. Possibly the greatest development has been in connection with the radial type with fixed cylinders. There is, of course, nothing new in this type, but little attention was paid to it until recently, one cause for this neglect undoubtedly being due to imaginary lubrication difficulties. It is obvious that this type requires the least length of crankshaft and crankcase for a given cylinder capacity, and therefore it should theoretically, at least, be the lightest per horsepower. It needs somewhat heavy piping arrangements, however, and it is possible that the more ordinary types of engines may in the end give equally good results.

The vertical type has the longest shaft and crankcase, and therefore should be theoretically the heaviest, the diagonal coming between the vertical and radial types. Nevertheless, the vertical type was more represented at Olympia than any other, and its practical advantages in construction may enable it to be made so nearly the weight of the other types that it may survive.

The radial type is made with any number of cylinders from three upward, ten being the usual limit. The vertical engines had either four or six cylinders, while the diagonal engines had eight or twelve cylinders. It is rather curious that the six-cylinder diagonal engine is never used.

The accompanying table gives general particulars as far as they are obtainable from the makers of various types of engines exhibited. The data are based on statements by the manufacturers. In some instances, the engines will give somewhat greater powers than stated if run at higher speed, while independent tests of other engines have shown that they will barely give the rated power. The weights in some cases include radiators, reducing gear for propeller, etc., which is indicated in a note to that effect. It will be seen that there is considerable variation in the proportions adopted by various makers for producing the same result. The weight per brake horsepower varies from less than two pounds to over six pounds, these extremes being both met with in engines which give very good results in practical flight. The cylinder capacity per brake horsepower varies from less than six cubic inches to nearly ten cubic inches, while the weight per cubic inch of cylinder capacity varies from 0.21 pound to 1.07 pound. It is clear from these figures that there are still two ways of making a light engine—the one to make it very light for its cylinder capacity and the other to get a great deal of power out of cylinders of a given size. Which principle will survive remains to be seen, and it is possible that success may best be obtainable by not going to the extreme in either direction. It is quite clear, however, that there is no tendency whatever to follow the practice used in the racing motor-car engines, tending to an extreme high-speed high-compression type.

The last column in the table is of some interest, showing as it does the mean pressure aimed at. This is calculated from

*Abstract of article in **Engineering** (London), February 28, 1913.

the given brake horsepower and the number of revolutions per minute, and is the mean pressure corresponding to the brake horsepower, no allowance having been made for engine friction. This latter, therefore, must be added to obtain the actual mean pressure in the cylinder. This, it will be seen, is in many cases so high that it appears as if the number of revolutions at which the power is obtained must be understated.

The Renault engine has been found extremely satisfactory by the British military authorities. It will be noted that this type of engine is one of the heaviest per horsepower in the list. The fact that such a heavy engine should be preferred by the military authorities to the lighter forms would indicate that the latter are not always as reliable as could be desired. The weights given, of course, in the case of the Renault engine include the reducing gear for the propeller, so that the weight is not fully comparable with the weights given in most of the other cases.

In comparing aeroplane engines, it must be remembered that lightness of the engine itself, even if combined with reliability, is not the only important point. In some cases very light engines are inconvenient to attach to the machine, and, therefore, require heavy base or foundation plates. In addition to this, economy of fuel is of considerable importance, because when long flights are made, an engine, no matter how light in itself, if it be extravagant in fuel consumption, may have no advantages as regards the total working weight of the aeroplane. If it consumes more fuel, there is the weight of the fuel, and the larger tanks and their support to be taken into account. Assuming a difference of one-quarter pound per horsepower-hour of fuel consumption, this would mean 2½ pounds per horsepower in a ten-hour run. For a 100-horsepower engine, this would mean 250 pounds exclusive of the additional weight of the tank.

Although the majority of the aeroplanes exhibited at Olympia were of British make, all of these except one were equipped with foreign engines. There were, however, some promising British engines exhibited in the section for aeroplane motors.

As an indication of what may be expected of a good aeronautical engine, it may be mentioned that it is considered that the weight of an aeronautical motor should not exceed four or five pounds per average brake horsepower developed in a five-hours' run, and that, if possible, the engine should run twenty-four hours without compulsory stopping, and that the propeller speed should be between 900 and 1200 revolutions per minute.

With regard to the aeroplanes themselves there was a general tendency in those exhibited at Olympia to make the construction more substantial than formerly. This is probably largely due to the fact that more power is now available in the modern engines and therefore extreme lightness is not so necessary as formerly. It will, therefore, be seen that the improvements in the engine are largely responsible for such improvements as may be met with in the construction of the aeroplane itself.

TABLE SHOWING CHIEF DIMENSIONS, ETC., OF AEROPLANE ENGINES

Name	Brake Horsepower	Type	Cooling	Cylinders							Weight	Revolutions per Minute	Weight per Brake Horsepower	Cylinder Capacity per Brake Horsepower	Weight per Cubic Inch, Cylinder Capacity	Mean Cylinder Pressure Corresponding to B.H.P.
				Diameter		Stroke		Number	Ratio of Stroke to Diameter	Total Capacity						
				mm.	in.	mm.	in.			cub. in.	lb.		lb.	cub. in.	lb.	lb. p.sq.in.
Anzani	30	Radial	Air	105	4⅛	120	4¾	3	1.14	190	121	1300	4.0	6.3	0.64	97
	45	Radial	Air	90	3½	120	4¾	6	1.33	280	154	1300	3.4	6.2	0.55	98
	60	Radial	Air	105	4⅛	120	4¾	6	1.14	380	200	1300	3.3	6.3	0.53	97
	80	Radial	Air	90	3½	130	5⅛	10	1.45	505	238	1250	3.0	6.3	0.47	101
	110	Radial	Air	105	4⅛	140	5½	10	1.31	740	308	1200	2.8	6.7	0.42	99
Austrian Daimler*	40	Vertical	Water	100	4	120	4¾	4	1.20	230	180	1450	4.5	5.8	0.78	94
	65	Vertical	Water	120	4¾	140	5½	4	1.17	387	250	1350	3.8	6.0	0.65	98
	90	Vertical	Water	120	4¾	140	5½	6	1.17	581	360	1300	4.0	6.5	0.62	96
	120	Vertical	Water	130	5⅛	175	6⅞	6	1.35	848	450	1200	3.7	7.1	0.53	94
Benz	100	Vertical	Water	130	5⅛	180	7⅛	4	1.38	585	.....	.....	.....	5.8	.....	.....
Clerget	60	Revolving	Air	120	4¾	120	4¾	7	1.00	580	200	.....	3.4	9.7	0.35	.....
Gnome	50	Revolving	Air	110	4⅜	120	4¾	7	1.09	487	168	1200	3.4	9.7	0.34	68
	80	Revolving	Air	124	4⅞	140	5½	7	1.13	720	192	1200	2.4	9.0	0.27	76
	160	Revolving	Air	124	4⅞	140	5½	14	1.13	1440	307	1200	1.9	9.0	0.21	76
Green	35	Vertical	Water	105	5⅛	120	4¾	4	1.14	253	177	.....	5.0	7.2	0.70	.....
	65	Vertical	Water	140	5½	146	5⅝	4	1.02	550	317	.....	4.9	8.4	0.57	.....
	100	Vertical	Water	140	5½	152	6	6	1.08	860	471	.....	4.7	8.6	0.55	.....
Laviator	80	Diagonal	Water	100	4	130	5⅛	8	1.30	498	276	1200	3.4	5.3	0.59	125
	120	Diagonal	Water	114	4½	160	6⅜	8	1.40	796	419	1200	3.5	6.7	0.53	107
	250	Vertical	Water	180	7⅛	200	7⅞	6	1.11	1860	1215	1050	4.9	7.5	0.65	101
Mercédès	70	Vertical	Water	120	4¾	140	5½	4	1.17	387	308	1400	4.4	5.5	0.80	103
	90	Vertical	Water	140	5½	150	5⅞	4	1.07	564	400	1300	4.5	6.3	0.71	97
	100	Vertical	Water	120	4¾	140	5½	6	1.17	581	444	1300	4.4	5.8	0.77	105
N. A. G.	55	Vertical	Water	118	4⅝	100	4	4	0.85	314	.....	.....	.....	5.7	.....	.....
	150	Vertical	Water	135	5⅜	160	6⅜	6	1.18	840	.....	.....	.....	5.6	.....	.....
Renault†	40	Diagonal	Air	70	2¾	120	4¾	8	1.71	225	242	1800	6.0	5.6	1.07	74
	70	Diagonal	Air	96	3⅜	140	5½	8	1.46	494	397	1800	5.7	7.0	0.80	77
	100	Diagonal	Air	96	3⅜	140	5½	12	1.46	740	639	1800	6.4	7.4	0.86	69
Salmson	80	Radial	Water	120	4¾	140	5½	7	1.17	675	286	1250	3.6	8.4	0.42	76
	110	Radial	Water	120	4¾	140	5½	9	1.17	870	305	1250	2.8	7.9	0.35	80
Wolseley†	60	Diagonal	Water	95	3¾	140	5½	8	1.46	486	410	1200	6.8	8.1	0.85	98
	80	Diagonal	Air	95	3¾	140	5½	8	1.46	486	370	1600	4.6	6.1	0.76	82
	120	Diagonal	Water	127	5	178	7	8	1.40	1100	630	1050	5.3	9.2	0.57	82

In all engines except the Wolseley, dimensions of cylinders are given by the makers in millimeters, and the inch dimensions are approximate equivalents.
*Weight includes radiator. †Weight includes reducing gear for propellers.

* * *

SPECIAL MACHINERY MAKERS

Many inquiries come to MACHINERY in the course of a year for the names of concerns engaged in the business of developing inventions, building special machinery, making metal and wooden models, and manufacturing mechanical novelties on a contract basis. All concerns prepared to do work to order will confer a favor by sending a statement to the editor of the classes of work for which they are best equipped.

THE DEVELOPMENT OF SKILLED MECHANICS

THE NECESSITY OF TRAINING WORKMEN—ORGANIZATION OF APPRENTICESHIP COURSES

BY C. J. MORRISON*

A difficulty which seems to be always present, and about which we are continually learning, is that of the scarcity of skilled mechanics. Nearly all manufacturing concerns experience this difficulty, more or less, according to the general conditions of business. Various excuses are given for the scarcity of good mechanics, but the fundamental trouble is seldom mentioned. In this, as in many other instances, people like to be deceived. The real trouble is that good mechanics are the product of a natural inclination toward the trade selected, an adequate education, and a careful training, and these conditions are not being met. In other words, a good mechanic must be made by proper methods of apprenticeship and these methods are found in very few plants. Not only is this the case, but even where the proper methods are used there are, in many cases, only a few apprentices. An extreme example of this condition is seen in a plant which employs 2000 men, and claims to have the most up-to-date and approved methods of apprenticeship, but is applying them on only two apprentices. The other extreme is to be found in a plant where there is no regular method of apprenticeship, and where the ratio of apprentices to mechanics is ten to one. Neither plant is turning out a supply of good mechanics. The various trade unions have recognized the evil of the second condition and have provided a maximum ratio of apprentices to mechanics, but they do not seem to have realized the danger arising from a condition where there are too few apprentices. It is perfectly practical to work out maximum and minimum ratios for various industries and different localities.

After the question as to the number of apprentices has been decided, the methods of instruction and the grades of apprenticeship should be determined. A longer time is required to learn trades requiring considerable skill, and a longer preliminary education is required in preparation for apprenticeship in some trades than in others. All of these factors must be carefully considered and provided for. As too much education is not likely to be attained, every encouragement and inducement possible should be given toward a liberal education. In order to be successful, any method of apprenticeship must endeavor to develop body, mind, character, and skill. The selection of material for apprentices is of great importance, and the employer should carefully investigate the suitability of a candidate for the trade that he wishes to learn. The investigation should take into consideration parentage, character, education and physical condition. In case a candidate appears favorable in the light of this investigation, he should be taken on trial and given every opportunity to demonstrate his fitness for the trade he has chosen, and also to determine for himself if the trade is to his liking. A trial period of three months would probably suffice in most cases. The importance of this trial period should not be overlooked, as it is important for the employer to secure apprentices who will eventually make good mechanics and also for the apprentices to be in the trade to which they are adapted. One does not have to look far to find numerous instances of "round pegs in square holes"—of good farmers being turned into poor mechanics.

During the trial period a record should be kept of the work performed and the candidates for apprenticeship should be under the direction of a shop instructor as much as possible. The various methods of hazing the new arrivals, in which even the foremen frequently take part, should be vigorously discouraged. An opportunity should be given each candidate to observe various phases of the work in order that he may be able to determine his ability for the trade he has chosen. This method at the same time enables the employer to determine the desirability of the candidate.

After the apprentice is chosen, his education and training should begin at once. As to the methods to be pursued, one can scarcely do better than to quote from Mr. G. M. Basford: "Another principle is mental training which, to insure complete success, must be parallel and simultaneous with the manual training in order that the boy may understand his work, know his materials, understand his methods, and know the reasons for what he does. For this, night schools will not suffice, and it seems fair to say that no recruiting system can approach the ideal which does not provide this mental training by taking the school to the boy; taking it in working hours and compelling his attention to it being as vital a part of his apprenticeship as the trade itself. This requires a substitute for the master of years ago in the form of a shop instructor who is capable of teaching the apprentice the theoretical and practical parts of his trade. It is important that the apprentice should come into contact with the real problems of the shop and that he should work as nearly as possible upon the same basis as the workmen, knowing that the product which he contributes is part of the general product of the plant. He should be taught to consider the commercial question of cost and the problem of management in the organization, so that he may see where the workman and employer fit into the general scheme. In mental training the same idea appears. This offers no field for the lover of 'pure mathematics,' but it offers a wonderful field for the man with practical ideas who understands the apprentice mind and knows the questions which are constantly arising with respect to the work of the shop. Mechanical drawing offers the readiest educational medium, and the development of this subject will lead to a clear view of the entire educational scheme. The brain and the hand must be trained simultaneously."

Mr. E. P. Bullard, Jr., who is considered an authority on this subject, speaks of the situation as follows: "The apprentice school is a necessary adjunct to any well organized apprentice system. Few concerns are large enough to support a school of their own, as is done at Lynn and Schenectady, and not every community is prepared to establish a technical school such as Winona or Cincinnati University. Fortunately, however, like industries usually locate in the same neighborhood, so that it is possible for manufacturers employing a similar class of labor to cooperate in the establishment and maintenance of apprenticeship schools. In Bridgeport, Conn., this has been done very successfully. The members of the local manufacturers' association, working in conjunction with the Y. M. C. A., have established a school for apprentices, who attend class two hours per day for five days a week. The boys are paid regular wages for the time they spend in the class room, and the entire expense of the instructor, who is especially employed for this purpose, is borne by the manufacturers who have boys in the school."

Too much emphasis cannot be laid upon the necessity of education in connection with shop training. This education must be of a practical nature and particularly adapted to each trade. Moreover, special provision should be made to accommodate the exceptional apprentices who are capable of rising above their fellows. These are the "cream" and are the future foremen, superintendents, and managers. In the shop, regular courses must be laid out and rigidly adhered to. The shop instructor should make up a regular schedule so that shifts can be made without delaying work or demoralizing the shop. Provisions should be made in the schedules so that apprentices showing a special aptitude for some particular branch of their trade can spend more than the regular allotted time on that branch.

So far only regular apprentice courses have been considered, but special courses intended for the instruction of grown men in specialized work are also important. The National Machine Tool Builders' Association has recognized the necessity of special apprenticeships and has laid out the following courses of instruction:

Turning: Two years.
Boring, Vertical and Horizontal: One and one-half year.
Planing: One and one-half year.
Milling: One and one-half year.

* Chief Engineer, Froggatt, Morrison & Co., 149 Broadway, New York City.

Drilling: One year.
Grinding: One year.
Erecting: One and one-half year.
Turret: One year.
Vise Work: One and one-half year.
Scraping: One and one-half year.

Shops that have tried these special courses are highly enthusiastic over their success. As it is hardly practical to send these men to school during working hours, a night school giving short courses of instruction on practical subjects should be established. The development of character in both the regular and special apprentices is largely in the hands of the shop instructor who, of necessity, must be a man whose character is beyond reproach. It is first necessary to gain the confidence of an apprentice, and then to try to correct any evil influences by bringing better ones to bear upon him and talking things over with him in a quiet way. While the moral development is exceedingly important, it will make no difference in the immediate shop output, but ten years from now it will bring results in plenty. The development of loyalty to themselves, their employers, and their country in the future generation of mechanics is worth more in dollars and cents than most of us realize. What can be better for everyone concerned than an earnest, loyal corps of employes, sober and industrious, wide awake and ambitious? Apprentice clubs are of great assistance in the development of character and are also of much help in an educational way. They may also be easily extended to assist in the physical development of the members. Wherever practical such clubs should be formed.

The work of organizing the courses of apprenticeship, selecting the lines of education, conducting the clubs and securing the instructors and teachers should come under the direct supervision of some high official of a concern, but the details should not be undertaken by him unless he gives up his other duties; this for the simple reason that he will not have the time to devote to the duties, and the subject is important enough to require the entire time of the best man obtainable. In the case of small shops, several could combine and place all of their apprentice problems in the hands of one man. There are those who will say, "All this sounds very fine, but it costs too much money." Here is the crux of the whole matter; these methods are not money wasters, but money earners. To quote again from Mr. Bullard: "Many large and successful concerns which have had apprenticeship systems in operation for a period of years are unanimous in their statements that apprenticeship systems do pay. If properly instructed and intelligently directed, their employment is more profitable than the employment of the so-called skilled workman who has been available in the past. Apprentices pay as producers during their term of service, as competent skilled journeymen when they have completed their course, and as industrially intelligent foremen and executives later on. Those boys who leave at the termination of their apprenticeship become staunch supporters of the mother-shop, always ready to say a good word for it."

In a concern which the writer recently visited, where very complete machine records are kept, forty per cent of the machines were operating at an average efficiency of forty-seven and a half per cent. This efficiency is not a comparison with an arbitrary standard, but with schedules that have been maintained and upon which other workmen have earned a substantial bonus. It would certainly pay this concern to have mechanics who would operate these machines at a rate nearer their normal capacity, for under the present condition there is not only a great loss in output, but a heavy increase in the unit cost. To make the matter perfectly clear, consider as a concrete example; standard time 8 hours, wage rate $0.30, and burden rate $0.24.

COST AT STANDARD TIME

Wages 8 hours at 30 cents	$2.40
Bonus	.48
Burden 8 hours at 24 cents	1.92
Total cost	$4.80

COST AT 47 1-2 PER CENT EFFICIENCY

Wages 16.8 hours at 30 cents	$5.04
Bonus	0.00
Burden 16.8 hours at 24 cents	4.03
Total cost	$9.07

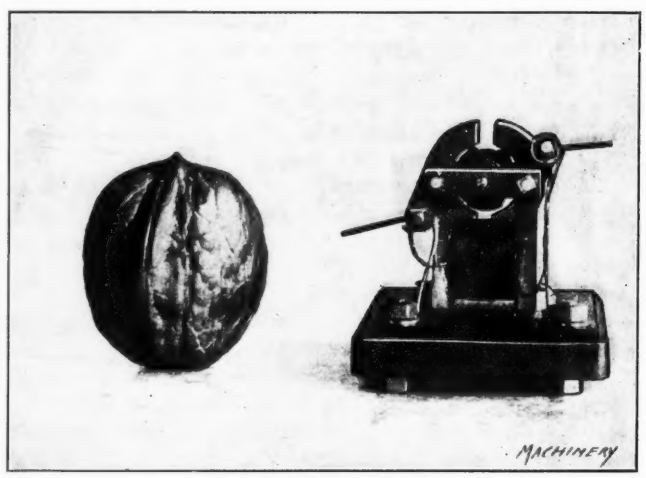
Here we have less than half the normal product at nearly double the cost, which is an average figure and must be multiplied by fifty to get the total for all the machines in the department. This, of course, only illustrates the loss due to lack of skilled mechanics, and there may still be a fear that the apprentices do not pay during the course of apprenticeship. The experience of one large concern that has very extensive courses of apprenticeship should allay this fear. In computing the cost of work by apprentices, they add to the wages all the expenses of conducting the courses, and to determine the rate per hour divide by the hours spent in the shop thus also placing on the work the wages for the hours spent in school. This concern has excellent records of the work of all employes and a consideration of these records shows that on the average the work done by the apprentices costs 36 per cent less than the same work done by mechanics. In other words, a job costing $10.00 when performed by a mechanic would cost $6.40 when done by apprentices. As apprentices pay both during the period of apprenticeship and afterward, it seems strange that the opportunity for such a profitable investment should be neglected. Let the manufacturers consider this question seriously and there will soon be less complaint about the scarcity of skilled mechanics.

* * *

SMALL ELECTRIC MOTOR

BY CHARLES L. WAGNER*

The accompanying illustration shows an electric motor which is so small that a five cent piece would afford more than enough space for it to rest upon. A fair idea of its size will be obtained from the illustration, where it is shown beside an ordinary English walnut. The idea of building this motor occurred to the writer from reading descriptions of various mechanical curiosities which appear from time to time in the different technical journals. In setting about this task, the idea was to determine just how little material it would require to construct a motor that would run as dependably as those



An Unusually Small Motor

of larger sizes. The base of the motor shown in the illustration is made of wood and plays no mechanical part in its operation.

The motor is of the under-wound type and contains only 25 feet of wire in its windings, 9 feet of which is on the armature. The motor is 1 inch high, 5/8 inch wide and 1/2 inch thick, and the armature is 5/16 inch in diameter. The armature shaft is 1/16 inch in diameter and the commutator, which is made in three segments, is 3/16 inch in diameter. This motor constitutes a perfect miniature of larger machines of the under-wound type and runs at 3000 R. P. M. It weighs 12 pennyweight, and when operating hums like the buzz of a bee.

* * *

There is such a wide margin between extreme tinkering with a machine and neglecting to keep it in order that there is but little excuse for indulging in the extremes.

* Address: 1002 Fourth St., Warren, Pa.

THE HEAT-TREATMENT OF GEARS AT THE BOSTON GEAR WORKS*

APPARATUS AND TREATMENT DEVELOPED WITH SPECIAL REFERENCE TO GEAR REQUIREMENTS

BY GEORGE L. COLBURN†

The heat-treating equipment of the Boston Gear Works, Norfolk Downs, Mass., is located in a separate fireproof building 26 feet by 45 feet, which consists of a steel framework covered with asbestos protected metal. Fig. 1 shows the arrangement of the equipment which comprises two carbonizing furnaces using coal as a fuel and having heating chambers 24 inches by 60 inches and also the following oil furnaces: Rockwell, 24 inches by 36 inches; American gas, 20 inches by 60 inches; Westmacott, 10 inches by 12 inches; Stewart, crucible and lead reheating. The temperatures are indicated by a Bristol thermo-electric pyrometer. A steel jib crane allows heavy work to be easily placed in or removed from the furnaces and cooling tanks.

Kinds of Heat-treatment

All the work usually carried on in an up-to-date hardening plant is handled at the Boston Gear Works, such as carbonizing and hardening low carbon and alloy steels, oil tempering the higher carbon and alloy steels, treating high carbon and tungsten tool steels, pack-hardening, annealing and drawing. The heat-treatments in use are mainly those recommended by the Iron and Steel Division of the Society of Automobile Engineers, known as the "S. A. E." treatments. These treatments cover carbon steels with 0.10 to 0.95 per cent carbon; carbon steel screw stock; 3½ per cent nickel steel with 0.15 to 0.50 per cent carbon; low, medium and high nickel chrome-nickel steel with 0.15 to 0.50 per cent carbon; low and medium nickel chrome-nickel vanadium steel; 1.0 and 1.20 per cent chrome steels with 0.95 and 1.20 per cent carbon; chrome-vanadium steel with 0.15 to 0.95 per cent carbon; and silico-manganese steel with 0.50 per cent carbon.

For special gear steels, referred to in the following list, special treatments are used which have been largely developed in the plant.

For 0.08 to 0.15 per cent carbon No. 1 machinery steel. Treatment *Z*.

For 0.15 to 0.25 per cent carbon No. 2 machinery steel. Treatment *I*.

For 0.35 to 0.40 per cent carbon No. 3 machinery steel. Treatment *E*.

For 0.40 to 0.50 per cent carbon oil tempering No. 4 machinery steel. Treatment *J*.

For 0.15 to 0.25 per cent carbon 3½ per cent nickel steel. Treatment *G*.

For 0.15 to 0.25 per cent carbon chrome-vanadium steel. Treatment *S*.

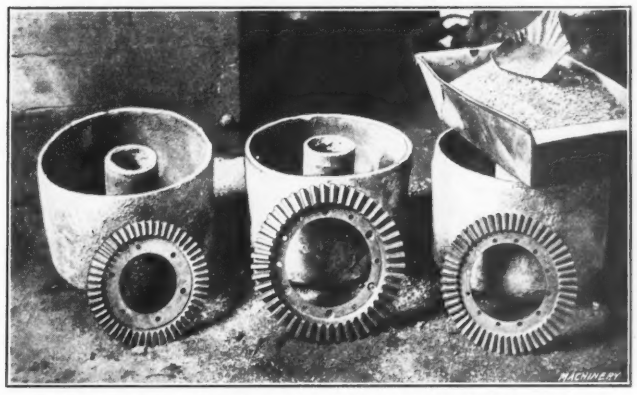


Fig. 2. Pots for casehardening Automobile Bevel Drive Gears

Treatment G

1. Carbonize between 1600 and 1750 degrees F. (1650–1700 degrees F. desired).
2. Cool slowly in the carbonizing material.
3. Reheat to 1450–1525 degrees F.
4. Quench.
5. Reheat to 1300–1400 degrees F.
6. Quench.
7. Reheat from 250–500 degrees F. (in accordance with the necessities of the case) and cool slowly.

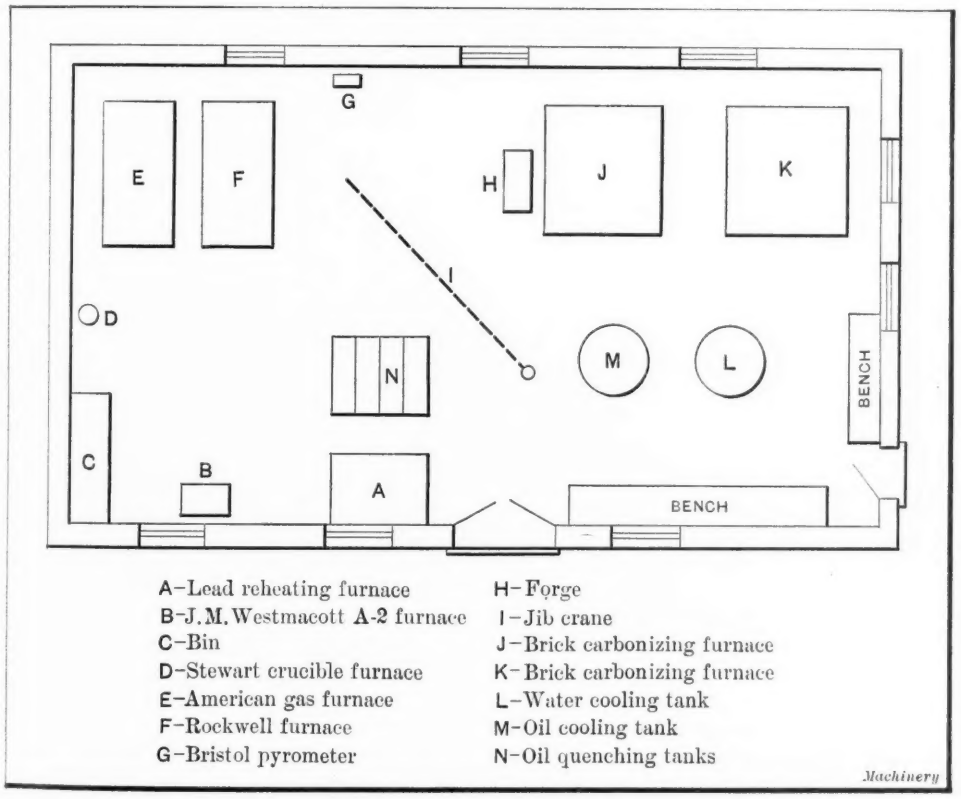


Fig. 1. Plan View of Heat-treating Plant showing Arrangement of Equipment

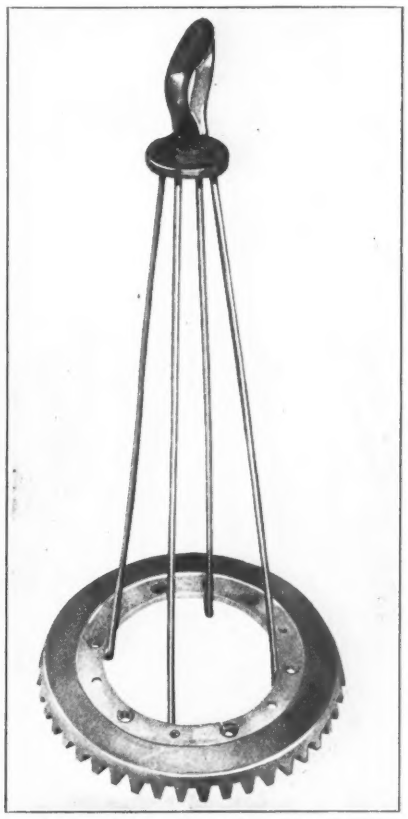


Fig. 3. Holder for dipping Ring Gears

Treatment S

1. Carbonize at a temperature between 1600 and 1750 degrees F. (1650-1700 degrees F. desired).
2. Cool slowly in the carbonizing mixture.
3. Reheat to 1600–1700 degrees F.
4. Quench.
5. Reheat to 1475–1550 degrees F.
6. Quench.
7. Reheat to 250–550 degrees F., and cool slowly.

* For further information on the heat-treatment of steel, see "The Pyrometer and Time Study in Steel Treatment," December, 1912; "Analysis and Heat-treatment of Low-carbon and Alloy Steels," August, 1912, and the articles there referred to.

† Address: Care of Boston Gear Works, Norfolk Downs, Mass.

Treatment E

1. Heat to 1500 to 1550 degrees F.
2. Cool slowly.
3. Reheat to 1400 to 1450 degrees F.
4. Quench.
5. Reheat to 600 to 1200 degrees F. and cool slowly.

Treatment Z

1. Carbonize at 1600 to 1650 degrees F.
2. Quench direct in oil.
3. Draw in oil 400 to 450 degrees F.

Treatment I

1. Carbonize at 1600 to 1650 degrees F.
2. Cool in pot.
3. Reheat from 1550 to 1600 degrees F. (1575 degrees preferred).
4. Quench in oil.
5. Reheat from 1350 to 1400 degrees F. (1375 degrees preferred).
6. Quench in oil.
7. Draw from 300 to 400 degrees F.

Treatment J

1. Heat from 1450 to 1500 degrees F. (1480 degrees F. preferred).
2. Quench in oil.
3. Reheat to 800 to 900 degrees F. (Sometimes drawn as

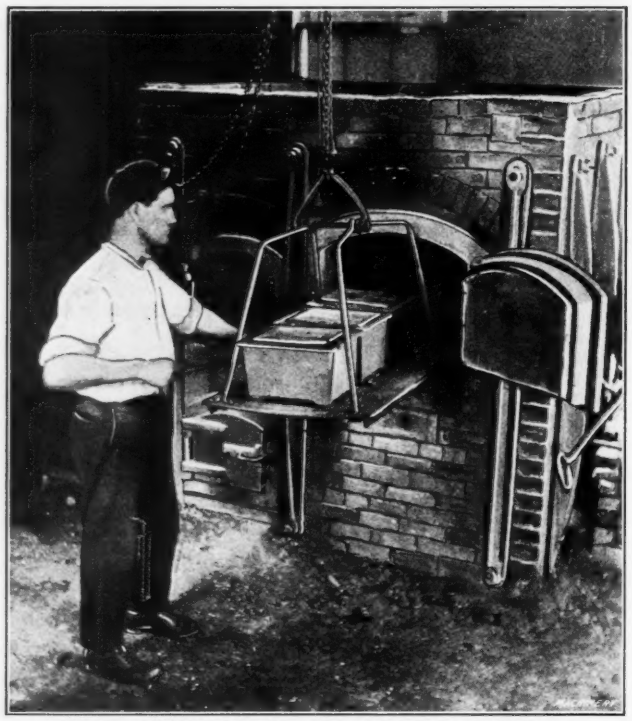


Fig. 4. Method of placing Carbonizing Boxes in Furnace

low as 600 degrees F. or as high as 1100 degrees F., according to requirements).

4. Cool slowly in the air.

There is considerable doubt relative to the proper heat-treatment for 0.35 to 0.40 per cent carbon machinery steel, as it is neither a casehardening nor oil tempering steel. This steel is largely used in its natural state. Treatment *E* is the one recommended by the S. A. E. for the treatment of 0.40 per cent carbon steel. Treatments *G* and *S* are also standard treatments of the S. A. E.

The method used by the Boston Gear Works for testing steel for heat-treating is to cut off ¼-inch disks from both ends of a bar after the rough ends have been cut off. The bar is stamped with a number and the disks with the same number. The disks are then heat-treated and broken by a ten-pound drop hammer, the height of drop and number of blows being recorded. Gear teeth are also tested by a Burgess drop hammer testing machine, the standard being a 15-tooth, 6-pitch 14½-degree involute gear of one-inch face. The average of a number of tests on casehardened standard test gears of No. 2 machinery steel required 31 blows with a ten-pound hammer dropped thirty inches to fracture a tooth.

Carbonizing Methods

The depth and quality of the case that is produced depends upon the duration of the heat-treatment, the temperature, the kind of carbonizing material used, the cooling process, and the temperature at which reheating and quenching operations are carried on. For casehardened gears, the best results are obtained with a refined case and fibrous core. Great care is required in packing gears in the pots with the carbonizing material. The pot covers are luted or sealed with fireclay and it is important that no gas escapes. More heats are obtained with malleable iron pots than those of ordinary cast iron, as the latter burn out more rapidly. Granulated bone,

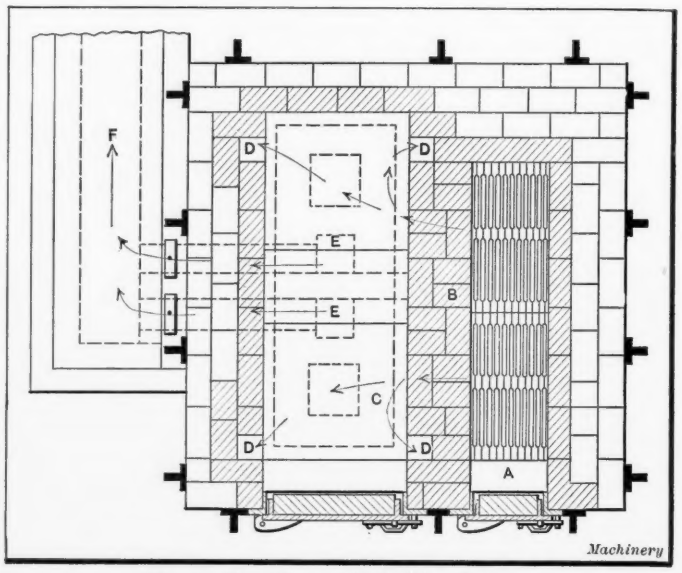


Fig. 5. Plan View of Carbonizing Furnace

charcoal and commercial carbonizing compounds are used for carbonizing.

Fig. 2 illustrates three casehardening pots for carbonizing automobile main-drive ring bevel gears. These pots have cored centers and lugs on the bottom to allow a more uniform circulation of heat than is secured with the use of ordinary cylindrical pots. The carbonizing material in the pan at the right is packed around the ring gears in the pots, after which the covers are sealed on with fireclay.

Fig. 4 shows the method of placing carbonizing boxes in one of the coal furnaces. The three rectangular boxes on the platform are suspended from an overhead jib crane in front of the open furnace door, ready to be pushed into the furnace. Fig. 5 is a sectional plan of the brick carbonizing furnace and Fig. 6 a cross-sectional elevation. This furnace is of the reverberatory type, the heat being deflected from the firebox *A* over a

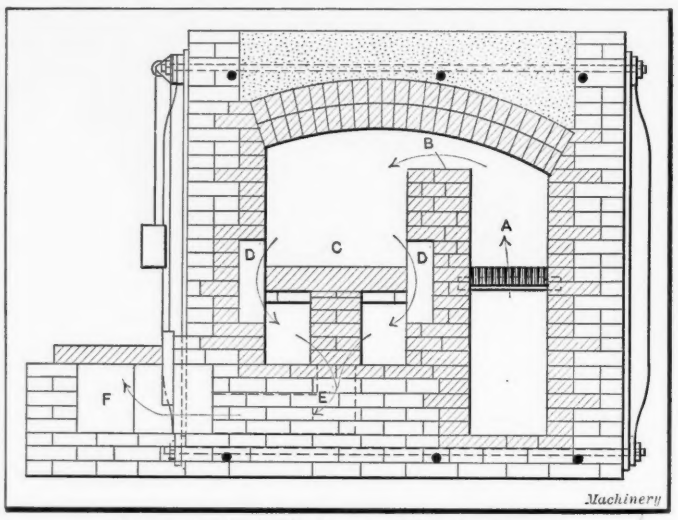


Fig. 6. Sectional Elevation of Carbonizing Furnace

bridge *B* and down upon the work, the firebox *A* and furnace chamber *C* being arched over. The gases from the furnace chamber *C* descend through four flues *D*. These flues unite in two ducts *E* which lead to the chimney flue *F*.

Casehardening

After carbonizing, the work is carefully reheated and treated according to one of the preceding methods. The quenching equipment includes a cylindrical steel water cooling-tank, three feet diameter by six feet deep, with a water inlet and outlet. The tank is placed vertically, with half of its depth below the

floor level. A similar oil cooling-tank, thirty inches diameter by six feet deep, is placed in an outer water tank, three feet diameter by six feet deep, which acts as a water jacket. This outer tank has a water inlet and outlet which provides circulation that keeps the oil at a low temperature.

Fig. 3 shows a special fixture for holding ring bevel gears for quenching which has given very satisfactory results, re-

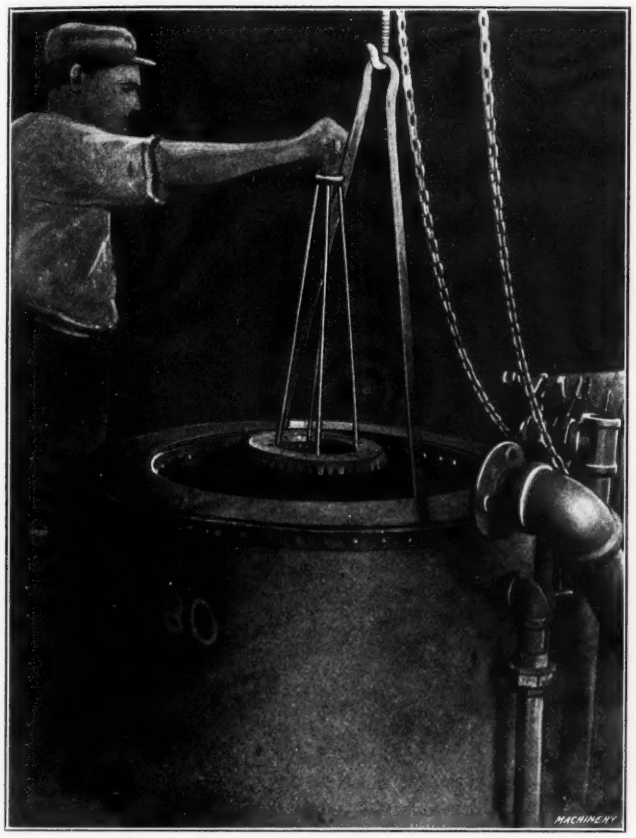


Fig. 7. Gear on Holder ready to dip in Oil

ducing the warpage to a minimum. Fig. 7 shows this fixture ready for use in the oil quenching tank.

Reheating and Oil Tempering

Fig. 8 shows a gear which has been reheated in the Rockwell oil furnace, and is about to be quenched for hardening. This picture also shows the Bristol pyrometer mounted on a post

Fig. 8. Removing Small Gear from Heating Furnace

at the right, and an American gas furnace at the left equipped for burning 34 distillate fuel oil. The four rectangular oil tanks at the front are used for quenching. A special grade of light oil is used for oil-hardening on most classes of work. Fig. 9 illustrates the reheating furnaces equipped with two lead baths, one bath taking work up to sixteen inches diameter and the other up to seven inches. This lead bath furnace, of the company's own design and construction, uses oil as a fuel, and is equipped with a pyrometer so that the temperatures are carefully indicated. The special tools for gripping and handling the various types of automobile gears in a scientific manner are a part of the outfit of the reheating process. An oil tempering bath, with a range up to 800 degrees F., is used for "drawing back" or tempering gears to the required degree of hardness. A special tempering oil is used, having a high flash point. Special thermometers are used in the tempering baths and all degrees of temperature up to 2300 degrees F. are under control. As the work passing through the heat-treating department requires this range of temperatures, it is necessary to have proper heating facilities and equipment that will retain fixed temperatures accurately.

Each particular grade of steel used in the manufacture of gears is stamped with a symbol and these symbols are charted in the hardening room so the hardener knows at a glance what kind of steel he is treating. Carefully written hardening orders, designating the required treatment that the material is to receive, are sent to the hardener with each lot of gears, so that the chances of error in this most important operation are reduced to a minimum. Cleaning baths and wire brush wheels are used to clean the gears after receiving the heat-treatments.

* * *

The popular conception of what constitutes a fireproof building material is somewhat vague, and often buildings are assumed to be fireproof that are nothing of the kind. For

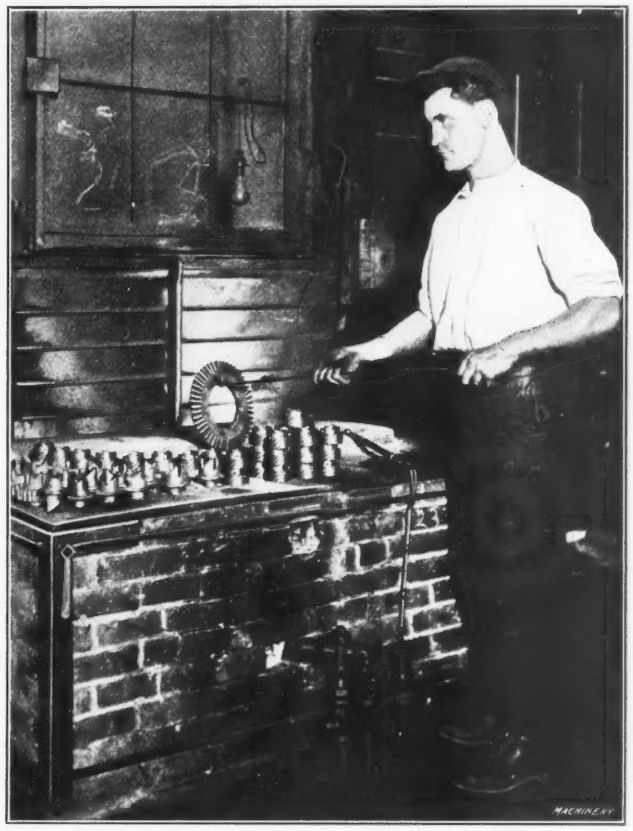


Fig. 9. Reheating Furnace equipped with Lead Baths

example, many people look upon steel construction as a fireproof construction because "steel cannot burn." Steel columns and girders, however, are anything but fireproof in the strict meaning of the word, when in the presence of inflammable materials. When heated, they will bend or buckle, thereby causing the collapse of a whole structure. The collapse of the Chamber of Commerce in Cincinnati a couple of years ago, due to a small fire that was soon put out, was an example of this. A peculiar experience with fireproof electric cables which also shows the difficulty of constructing anything that will, under all circumstances, be proof against fire or heat, is reported from England. In a generating station, certain cables covered on the outside with fireproof braid were destroyed in a remarkable way. The fire itself was a comparatively small blaze started by an accidental short circuit and was promptly extinguished. It appears, however, that the short circuit had enormously overloaded the cables so that the stranded copper cores were heated to a red heat. The expansion of the cores rent the fireproof braid and exposed the rubber insulation underneath to the air so that it caught fire and was destroyed by the flames.

HARDENING HAMMER DIES*

HEATING AND PACKING—QUENCHING AND QUENCHING BATHS—TEMPERING

BY WILLIAM E. SNOW†

The hardening of large die-blocks, for either hot or cold work, is a serious problem to most manufacturing concerns, because, in addition to the cost of the steel, a very heavy expense for the labor of die-cutting is involved. The total cost of a pair of dies frequently ranges from one hundred to three hundred dollars or more, so that the loss of a single die in hardening is a serious item of expense, aside from the long time required to replace it. Furthermore, a hammer die that is subjected to the blows of a drop weighing from twelve hundred to eighteen hundred pounds, must be very skillfully heat-treated in order to stand up under the repeated heavy shocks without breaking. For this reason, many concerns send their expensive dies away to be hardened, but as this is not always convenient, a description of the methods and equipment of the expert die hardener may be of benefit to those who wish to do their own hardening.

The requisites for a properly hardened hammer die are: a perfectly hard face, with a sufficient depth of hardening to prevent the surface from sinking; sharp, clean edges and corners; a soft, tough body to insure against breakage; freedom from warping or change of size, due to shrinkage of the steel in cooling. The face of the die should be not only file hard, but should stand a smart blow, of a hardened steel hammer without perceptible dent. With any good uniform die steel these qualities may be readily obtained by the following treatment.

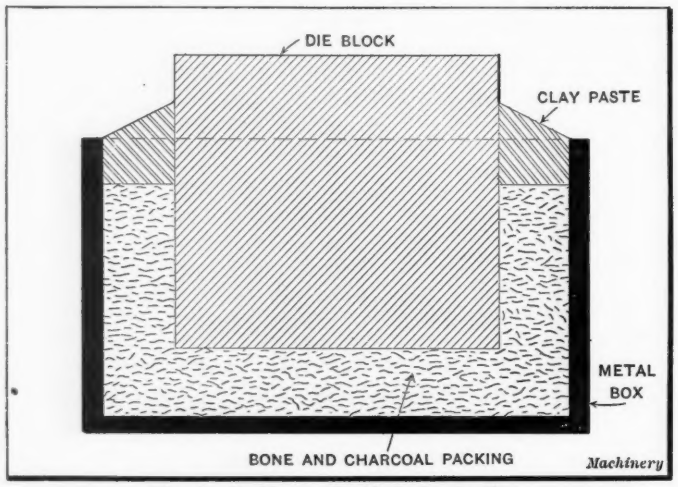


Fig. 1. Packing a Die-block for heating

Heating and Packing for Heating

For heating the dies, an oil or gas furnace is the ideal equipment, but a coal or coke-fired muffle capable of maintaining a temperature of at least 1600 degrees F., will answer the purpose, provided the temperature can be held constant. The great advantage of the gas or oil furnace over the coal or coke-fired muffle is the greater rapidity with which the temperature can be raised or lowered, and the ease with which it can be held constant.

A temperature-indicating device, either pyrometer or pyroscope, is an absolute necessity if good results are to be obtained, as it is impossible to judge the temperature by the eye with sufficient accuracy for hardening this class of dies. A temperature difference of twenty-five degrees has a very noticeable effect upon the die, while a fifty-degree variation may spoil it entirely, particularly if at the critical high heat demanded with some of the best alloy steels. Under certain conditions, a temperature difference of even seventy-five degrees cannot be detected by the eye with certainty. No guesswork should be permitted to enter into the hardening of dies, as a few failures cost many times the price of a good pyrometer or pyroscope.

Dies should always be packed for hardening. To pack a die properly, mix a thick paste of linseed or cottonseed oil and powdered bone-black. Paint the face of the die with a thick coat of this paste, which will bake on under the action of the heat and protect the delicate edges from oxidation through contact with the air.

Next, take a shallow sheet-iron or cast-iron box, an inch or so wider than the die all around, and fill the bottom to the depth of an inch with fresh bone and powdered charcoal, mixed half-and-half. Place the die, face down, in the center of the box, taking care not to displace the paste on the face. Now fill in between the sides of the box and the die with more bone and charcoal, mixed half-and-half, right up to the top of the box. The die should set in the box only deep enough to allow its top edge or back to project about an inch above the top of the box, for convenience in handling with the tongs when removing from the box to quench. Now cover the space between the upper edge of the box and the sides of the die with a thick layer of wet clay paste, which will bake on and keep the charcoal from burning out, and the die is ready for the furnace. Fig. 1 shows the arrangement of the die and packing in the box.

Die steels in general give the best results when quenched at the temperature which produces the densest, finest-grained fracture. Unless you know exactly what this temperature is for the steel you are using, first ascertain it by placing a number of small pieces of the steel in the furnace (they do not need to be packed for this purpose) and hardening and fracturing them at different heats, starting at a low heat and gradually working up until you obtain the greatest refinement of the grain of the steel. Note the temperature at which it is obtained, as that will be the correct quenching heat. Do not assume, because you may be getting good results from your dies, that your heat is correct. Make certain, and you may get even better results.

The dies should be put into the furnace as soon as it is lighted and allowed to "come up" with it. If the correct quenching temperature for the steel is, say, 1500 degrees F., then the furnace should be checked when the pyrometer indicates 1400 degrees, and the dies allowed to soak at that even heat for three or four hours. Then the heat should be slowly raised to the final 1500 degrees, and held at that point for one or two hours longer, according to the size of the die, large blocks requiring a longer time to attain an even temperature throughout than small ones. Then the die is ready for quenching.

Do not attempt to hurry the heating of dies, as it takes several hours for the heat to penetrate the packing and thoroughly soak into the die-block, until the outside and the center are the same temperature. More dies crack in cooling, or afterward, from insufficient heating than from any other one cause. With this in mind, five hours is the least permissible total time in the furnace, and seven to eight hours is much safer. Most expert die hardeners put their dies into the furnace in the early morning, and take them out in the late afternoon.

Care must also be taken that the dies get an even heat in the furnace. As may readily be proved by manipulation of the pyrometer rod, some parts of a furnace are frequently much hotter than others; so, to avoid getting one end of the die hotter than the other, it should be occasionally reversed, end for end, while heating.

Cooling and Cooling Baths

The proper cooling of dies is as essential to good results as the heating itself. Even when a die has been correctly heated, improper cooling may make it too soft, or warp it, or even cause it to crack, rendering it totally unfit for use. The requisites for properly cooling a die are: a sufficient flow of cold water to cause it to harden to the necessary degree of surface hardness to withstand wear, and to a sufficient depth to prevent the surface from sinking under heavy blows of the hammer; and means for applying the water in such a manner as to cause the least possible warping. The rate of cooling has

* For further information on hardening hammer dies see "Drop-Forge Die-Sinking—2," August, 1912.

†Address: 24 Milk St., Boston, Mass.

an appreciable effect upon the initial heat required to make a die hard enough. If the water equipment permits of very quick cooling, a somewhat lower heat may be used, and the lower the heat, the less trouble from warping. It is useless to attempt to cool a die-block of any appreciable size in a tank of still water, as the heat in the large body of metal draws the surface faster than the water can harden it. It will harden upon the immediate surface, under such treatment, if heated enough, but there will be no depth to the hardening, and the face will soon sink in use, causing cracks to form. A properly hardened die should have a depth of hardening of from ¼ to ¾ of an inch, according to the steel used. Oil should not be used to harden hammer dies, as its cooling action is not sharp enough to produce a sufficient depth of hardening.

In cooling, the face of the die should receive a sufficient flow of cold water to cause it to harden to the greatest possible depth. The back of the die should at the same time receive a similar treatment, to make the shrinkage of face and back equal, thereby preventing warping. The sides of the die may be left to take care of themselves. Dies may be hardened either face up or face down, according to the equipment used. Fig. 2 shows a most desirable arrangement for hardening dies face down. *A* is the cooling tank; *B*, the die; *C*, a six-inch water pipe; *D*, an eight-inch overflow pipe; *E*, an inch-and-a-half water pipe; *F*, a quick-opening valve; *K*, a flattened nozzle with a long, narrow opening; *G*, a quick-opening valve; and *J*, adjustable rods for supporting the die at the two ends.

To harden a die, the water level is lowered to the line *H*, by means of the two-inch drain *I*. The packing box containing the die is then removed from the furnace and set upon the floor. The back of the die, which protrudes an inch or more above the packing, is grasped firmly with a pair of tongs and lifted from the box. If the bone paste, which has baked on in a hard crust, sticks to the face of the die, no attempt is

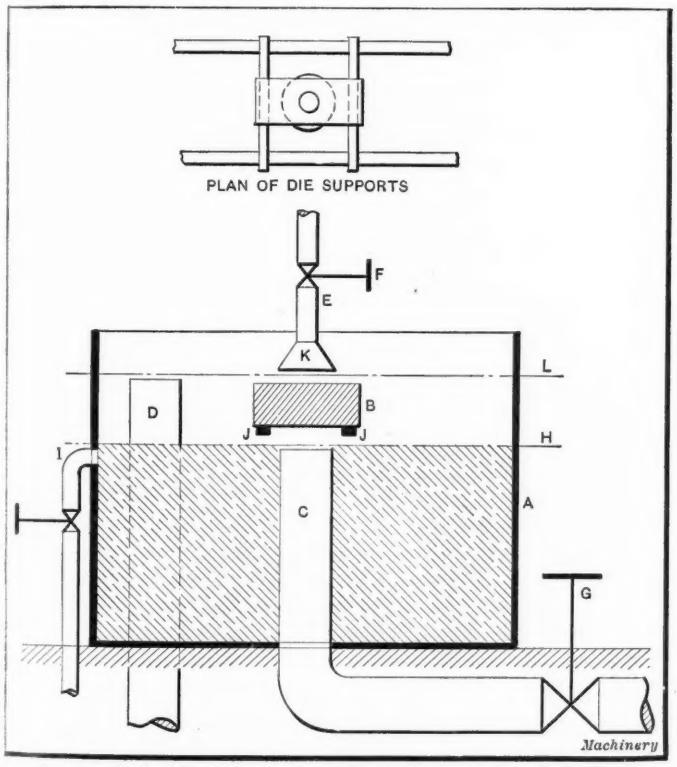


Fig. 2. Cooling Bath arranged to throw Water against Both Faces of the Die

made to remove it, as it serves to keep the air from the face of the die until it is under the water, at which time the paste will crack and fly off. The die is immediately placed in the tank, face down under the elongated nozzle *K*, the two ends resting upon the adjustable supports *J*. When in this position, the die should be central over the pipe *C*, as well as central under the nozzle *K*. As soon as the die is in place, the valve *G* is turned on, which permits a large volume of water under pressure to flow out of the pipe *C* up against the face of the die. This flow of water rapidly raises the level in the tank from the line *H*, so that in the course of a few seconds the whole die-block is immersed. Just before the water level reaches the top of the die-block, the valve *F* should be quickly opened, permitting a small stream of water at high pressure to strike the back of the die, thus equalizing the cooling strains. When the water reaches the level *L*, an inch or two above the top of the die, the overflow pipe *D* takes care of it and prevents it from rising further. The flow from pipes *C* and *E* is allowed to continue until the die-block is cool enough to handle, which requires only about two minutes from the time the water is turned on, for a medium-sized die. This is very rapid cooling, as this same die-block, if put in a tank of still water to cool, would retain a visible red for five or six minutes. The application of the water to both face and

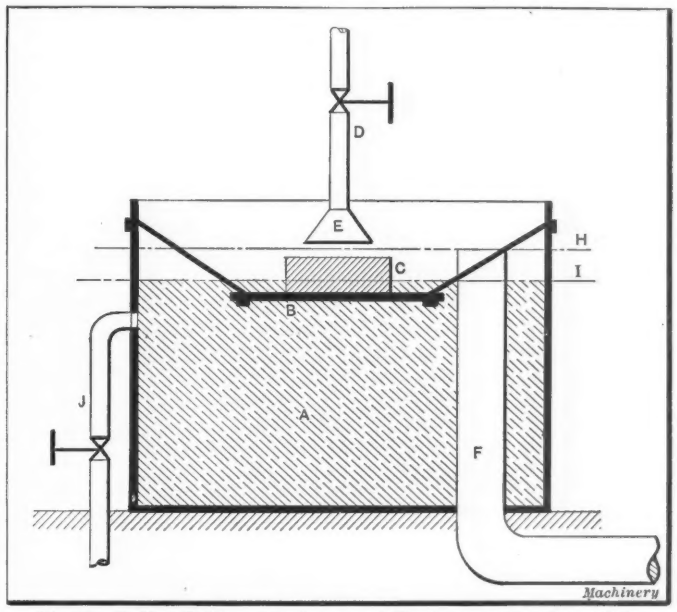


Fig. 3. Cooling Bath arranged to partially immerse the Die and to throw Water against the Top Face of the Die

back of the die, equally, balances the cooling strains and does away with warping.

As it is not always convenient or possible to get a six-inch water supply even at low pressure into the hardening room, an alternative scheme is shown in Fig. 3. This is a method for hardening the die face up, and requires only a small water supply, an inch-and-a-half pipe at forty to fifty pounds pressure, such as is obtainable in most towns. With this arrangement we have the tank *A*, the iron plate *B*, supporting the die-block *C*, the inlet pipe *D*, fitted with the nozzle *E*, and the overflow pipe *F*.

In operation, the water is lowered by means of the drain *J*, to the level *I*, which covers the plate *B* about an inch deep. The die is removed from the furnace as before, and placed upon the plate *B*, centered under the nozzle *E*. The water that covers the plate, and the cold iron itself, rapidly cools the back of the die. As soon as the die is in place, the valve *D* is opened, and the water from the nozzle *E* strikes the face of the die. The water level in the tank rises rapidly to the level *H*, completely immersing the die, and the overflow pipe *F* holds it there. The water from the pipe *D* is permitted to flow upon the face of the die until cool enough to handle.

With this last arrangement, the flow of the water from the pipe *D* must be so regulated as not to cool the face faster than the back of the die; otherwise warping will occur. With a little practice this method will produce nearly as good results as the double pipe arrangement, except that the dies will have a little greater tendency to warp. Either method, though, is far ahead of the common tank in this respect.

Tempering in Oil

Dies should be tempered, or drawn, as soon as they are cool enough to remove from the tank. If not drawn at once, they are liable to develop cracks. For tempering, the proper equipment consists of a small tank of oil, a suitable burner underneath for heating it, and a high-temperature thremometer. Any high-grade cylinder oil of high flash point is suitable for the work. Low-grade oils smoke unpleasantly at moderate heats, and will not stand high temperatures. The drawing temperatures of die steels range from 350 to 480

degrees F. The color barely starts at 350, while 480 produces a very full straw.

Heat the oil bath to the temperature corresponding to the desired color, immerse the die-block completely in the oil, and let it soak for an hour or more. Remove from the oil, quench in water or cool oil, and place in a warm, even temperature over night, or until ready to use. A lead bath should not be used for dies, as the lead will stick to the intricate corners and angles and cause trouble. Oil is the only proper medium for this purpose.

Do not attempt to draw die-blocks by simply starting the surface color on a hot plate or in a furnace, as is common practice in many shops. This heats only the immediate surface, without relieving the greater cooling strains that are locked into the body of the metal. For hammer dies under heavy service it is most important that these strains be thoroughly released; otherwise the dies are apt to crack or break down prematurely. Surface-drawn die-blocks should be classified with the methods of the old-fashioned spring maker who tempered his springs by rubbing them with a charred pine stick, the sparks given off by the burning wood presumably indicating the degree of heat.

Points to Remember

1. Fresh bone has a decided carbonizing (surface hardening) effect upon the steel. The ordinary mixture is half bone and half charcoal. More bone gives greater hardness, more charcoal less hardness, for a given heat. The proportions of bone and charcoal should be varied to suit the work in hand. Increase of hardness means increase of brittleness.

2. Unless the face of the die is treated with a jet of water under pressure, the sunken parts of the pattern will not harden equally with the face. When dipped into still water to harden, steam forms in the die cavity, which keeps the water from entering to properly harden these parts of the die. To overcome this, the water must be forced into the sunken parts of the die by pressure sufficient to overcome the resistance of the steam that is formed by the heat.

3. The most skillfully hardened dies will not give good service unless set absolutely parallel as to their surfaces under the hammer. In a block that is set in the hammer or anvil a little "off" the strains created are enormous, and breakage is sure to result speedily.

4. Hammer dies must have *depth* of hardening, as well as surface hardness, to withstand the heavy blows to which they are subjected. Other kinds of dies do not need this, because the work is light, and service is merely a matter of wear of their edges. Sinking of the face of a hammer die means the development of cracks every time, so the steels used should be selected for their deep-hardening qualities. This means alloy steels, generally, as few carbon steels will harden to a depth of more than 1/16 inch, which is entirely inadequate for this service.

* * *

The rigid accuracy of tooth form and spacing required of gears for high-grade automobiles has made many changes in gear cutting practice. Hardened gears are desirable but very expensive and difficult to produce when the teeth are hardened after they are cut. Unless extraordinary care is taken, the teeth and spacing will be perceptibly distorted. Grinding the teeth may be accomplished and is being done with satisfaction, except on the score of cost. To avoid the troubles incident to hardening after the teeth are cut, some automobile makers are cutting their gears by the planing process after hardening. This also is a slow and costly process but is simple and reliable in results. The planing cuts are taken at slow speed and turpentine is used instead of soda water or lard oil. The work produced is beautiful in finish and, of course, as accurate as the general limitations of the cutting process permit. The hardness of these gears as shown by the scleroscope test is 75 to 80.

* * *

The Bullard Machine Tool Co. is cutting large bevel wheels for boring mills from heat-treated chrome-nickel steel, having a hardness of 35 to 40 scleroscope test. The gears are not heat-treated after cutting, thus changes of tooth shapes and spacing incident to heating and quenching are avoided.

A MODERN APPRENTICESHIP SYSTEM

BY A. J. SCHNEIDER*

The necessity of training apprentices is just as much of a "live question" to-day as it has been at any time during the history of the metal trades, and the purpose of this article is to show the advantages of the "Apprentice Schedule" developed and used by the Cincinnati Planer Co., Cincinnati, Ohio, over the old contract system which was recently discarded. Having seen both systems in use, the writer is in a position to discuss the advantages and disadvantages of each.

To begin this discussion let us make a study of the contract system by supposing that the factory has an opening for a machinist apprentice. Such being the case, the employment department will either send for a boy who has already made application or else take steps toward securing new applicants. A study has been made of methods of advertising for boys and a standard advertisement has been developed that is placed in the newspapers which find their way to the homes of the working people. When an applicant calls and is interviewed, he is told that it takes four years to learn the trade, that he will be sent to school a half day each week with pay,

SCHEDULE

Under Which Apprentices are Received for Instructions at the Works of

THE CINCINNATI PLANER CO.

1

Applicants for apprenticeship must have reached the age of sixteen years.

2

The apprenticeship term shall cover a period of four years, during which time the apprentice must work under such shop rules and regulations as may be in force, and said four years shall be divided into eight (8) periods of 1,350 hours each, (about six months).

3

Apprentice shall receive ten cents per hour to start and will be given an increase of one cent per hour, every period of 1,350 hours, (about six months).

4

Overtime, shall be counted in favor of apprentice, and all time absent shall be made up.

5

Each apprentice shall be allowed one-half day each week on full pay for that half day, to attend the Continuation School.

6

Each apprentice shall be allowed the privilege of profiting by premium work or any other special system of pay or benefit in use in this plant.

7

It is the pride of every first class machinist to possess a tool chest and a fine set of tools; with this idea in view, each apprentice must purchase at his own expense, such small tools as he may require in the different departments, namely, a scale, calipers, hammer, surface gauge, etc.

8

Each apprentice shall have the privilege of one week's vacation each year, without pay at such time as may be mutually agreed upon one week in advance, and the loss of time need not be made up.

9

Should the conduct or work of apprentice not be satisfactory to employer, he may be dismissed at any time without previous notice.

10

Apprentice shall not receive this schedule until after one month's trial, when he will be sent to the Continuation School and receive this Schedule, signed by the Company.

11

To impress upon the Apprentice the value of Saving, the Company will open a Savings Account in the name of the apprentice, depositing to his credit $2.00 each month in some good Savings Bank, with interest at 3 per cent. No part of this Bonus however, will be given to the apprentice until he has satisfactorily completed his four years apprenticeship.

12

A handsomely engraved Diploma issued by The National Machine Tool Builder's Association and signed by an officer of our Company will be presented to the apprentice on completion of his term.

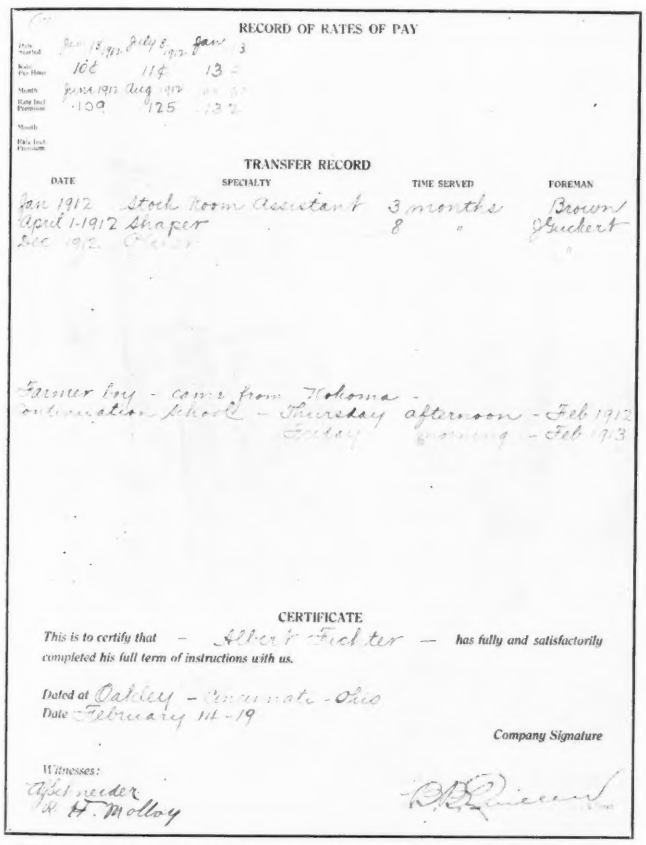
Fig. 1. Rules and Regulations under which Apprentice is employed

what the rates of payment are and other details; and finally he is told that he *must sign a contract*. This is where the mistake is made. The boy frowns and becomes confused. He doesn't want to sign that contract and although he may not say so, you can see it. There may be no very good reason, but the boy simply doesn't want to bind himself in such a way. Perhaps he feels that he is being forced to do something. He is. You ordinarily go against a boy's nature when you try to force him. If you ask this one why he doesn't want to sign the contract, he will tell you that he doesn't know that he will like the work, or that if he signs a contract for four years he might want to make a change after having worked for two or three years. Say what you will, most boys prefer to work as apprentices without signing a contract. The employer is not protected or benefited in any way by the contract, so what is the use of making a boy sign it if he doesn't wish to? The chances of employing the boy are diminished if such a course is followed, and the signing of the contract by him, his father and witnesses, is but an imaginary protection to the employer. In the first place it is not legal, and a boy cannot be compelled to work under the contract if he doesn't want

* Cost Accountant, Cincinnati Planer Co., Cincinnati, Ohio.

to. If he is compelled to work, it is exceedingly doubtful if satisfactory results will be obtained. Don't be selfish; look at the subject from both sides; he may do very well with some other employer or in some other line of work, and he may have very good reasons for not being satisfied. There are probably boys in your own shop who received part of their training in other factories and they are probably good boys at that.

The accompanying illustrations show the apprentice schedule which has been adopted by the Cincinnati Planer Co. This schedule is printed on the four pages of a double sheet 8½ by 11 inches in size. Fig. 1 shows the first sheet which contains the rules under which the apprentice is employed. Figs. 2 and 3 show the two inside sheets of the schedule which is used by both the company and the boy to keep a record of changes, rates, time served, etc. The form shown in the illustrations is a sample of one of the schedules now in use, and the following is a brief outline of the method followed in employing apprentices. Boys are not accepted unless they are over 16 years of age and, as previously stated, the period of apprenticeship is four years. A record of the time served is kept and the apprentice is given an increase in pay of at least one cent per hour about every six months, the increase depending


RECORD OF RATES OF PAY

Date Started — Jan 18 '12 — July 8 '12 — Jan 3

Rate Per Hour — 16¢ — 17½ — 13

Month — June 1912 — Aug '12

Rate Incl Premium — 20 — 25 — 17½

TRANSFER RECORD

DATE	SPECIALTY	TIME SERVED	FOREMAN
Jan 1912	Stock Room Assistant	3 months	Brown
April 1-1912	Shaper	8 "	Guckert
Dec 1912	[illegible]		

Farmer boy - came from Tokoma - continuation school - Thursday afternoon - Feb 1913
Friday morning - Feb 1913

CERTIFICATE

This is to certify that — Albert Fichter — has fully and satisfactorily completed his full term of instructions with us.

Dated at Oakley - Cincinnati - Ohio
Date February 14 - 19

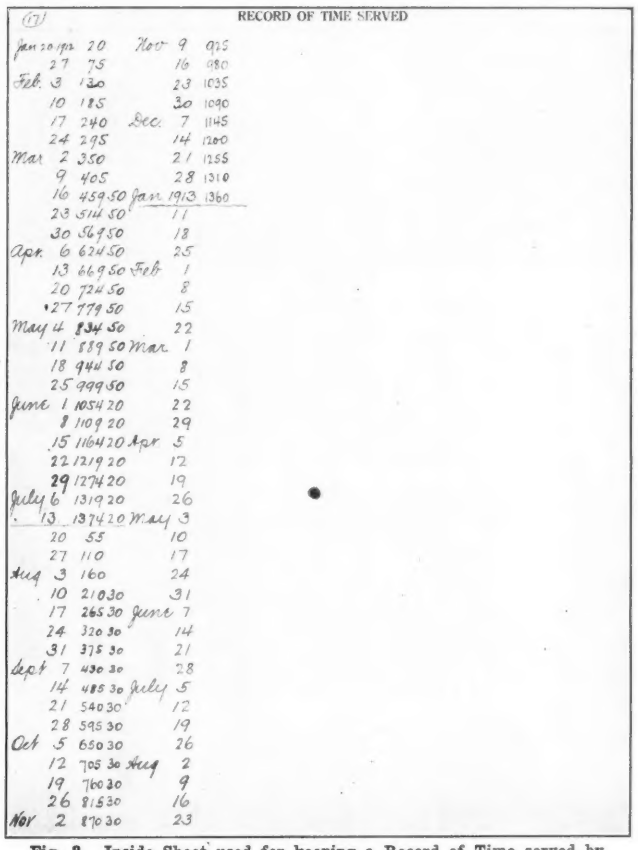
Company Signature

Witnesses:
Albert Neider
H. Molloy

Fig. 2. Inside of Schedule used for keeping Record of Rates of Pay

upon his advancement and ability. Credit is given for exactly the amount of time which the apprentice puts in in the shop, plus school and vacation time. He is sent to a continuation school half a day each week, where he learns how to make and read drawings and blueprints and other things that will help him to become more efficient in his work. A method of rewarding him for rapid advancement is provided by allowing him to benefit by any premium or other system of pay which is used in the plant.

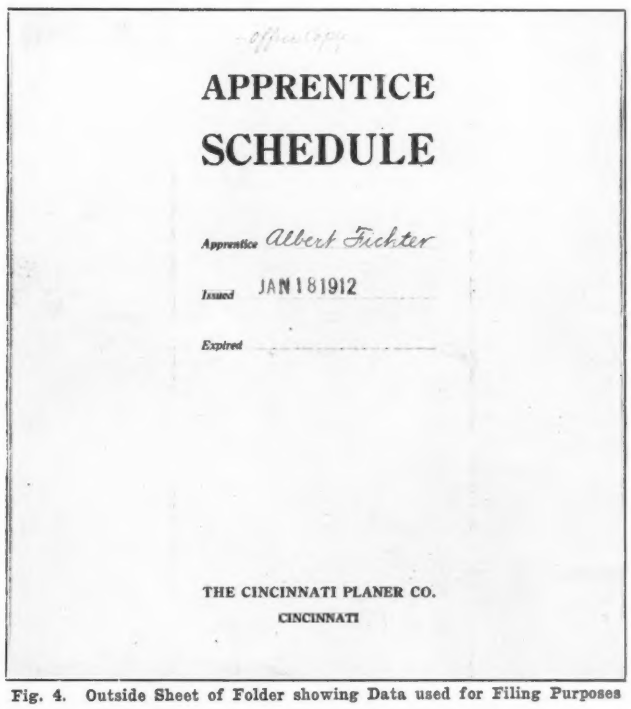
It has been recognized that a boy will naturally take more interest in his work if he owns a complete set of tools, and consequently each apprentice is asked to provide himself with a good tool box and a set of tools. It is felt that a boy who works faithfully during the year is entitled to a vacation and, therefore, each apprentice is offered one week's vacation. Paragraph 11 of the schedule shown in Fig. 1 represents a change from the old idea of paying the apprentice a bonus of $100 on the completion of his term. This method has been modified by opening a bank account for each boy at the end of his first month's employment. A bank book is issued in his name and he is credited with $2 for every month's work, the deposits so made drawing 3 per cent compound interest. It is believed that this course offers an inducement for the boy to save money. Another advantage is that a boy can see his bonus increasing every month, and knowing that he cannot use it until the expiration of his term, he is more anxious to remain until its completion. The bank book is given to the boy twice


(17) RECORD OF TIME SERVED

Jan 20 '12	20		Nov	9	975
	27	75		16	980
Feb	3	130		23	1035
	10	185		30	1090
	17	240	Dec	7	1145
	24	295		14	1200
Mar	2	350		21	1255
	9	405		28	1310
	16	459.50	Jan	1913	1360
	23	514 50		11	
	30	569 50		18	
Apr	6	624 50		25	
	13	669 50	Feb	1	
	20	724 50		8	
	27	779 50		15	
May	4	834 50		22	
	11	889 50	Mar	1	
	18	944 50		8	
	25	999 50		15	
June	1	1054 20		22	
	8	1109 20		29	
	15	1164 20	Apr	5	
	22	1219 20		12	
	29	1274 20		19	
July	6	1319 20		26	
	13	1374 20	May	3	
	20	55		10	
	27	110		17	
Aug	3	160		24	
	10	210 30		31	
	17	265 30	June	7	
	24	320 30		14	
	31	375 30		21	
Sept	7	430 30		28	
	14	485 30	July	5	
	21	540 30		12	
	28	595 30		19	
Oct	5	650 30		26	
	12	705 30	Aug	2	
	19	760 30		9	
	26	815 30		16	
Nov	2	870 30		23	

Fig. 3. Inside Sheet used for keeping a Record of Time served by Apprentices

a year (at the time of interest payment) and he is told to take it home, show it to his people and then return it before the first of the following month. Close cooperation of parents is invited and they are welcome to call upon the management at any time. In case of trouble of any kind, the parent is


APPRENTICE

SCHEDULE

Apprentice Albert Fichter

Issued JAN 18 1912

Expired

THE CINCINNATI PLANER CO.
CINCINNATI

Fig. 4. Outside Sheet of Folder showing Data used for Filing Purposes

sent for and it has been found that a discussion of the difficulty between the parent and management will improve the boy's future conduct. The best apprentice is usually the one whose parents take an active interest in his work and advancement.

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JUNE, 1913

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UNNECESSARY EYE-STRAIN IN THE DRAFTING-ROOM

The weakening of the eyesight of draftsmen and the various nervous ailments, headaches, etc., that often follow, are frequently due to wholly unnecessary eye-strain. The eyesight is not weakened by continuous use entirely, but rather by use under improper conditions. Adequate lighting, both natural and artificial, is a primary requirement, but there are other causes of eye-strain in the drafting-room that are perhaps just as important. The making and reading of drawings with lines of inadequate thickness put the eyes to a test that is far more injurious than is their continuous use. The making of tracings from pencil drawings where the lines are so fine that they are barely distinguishable through the cloth, puts an extreme strain on the eyes.

With many draftsmen it seems to be a hobby to use pencils entirely too hard to produce a line of adequate thickness. Many draftsmen will say that if they use a softer pencil, which will produce a strong, easily distinguished line, it will smudge on a drawing upon which they may have to work for a considerable length of time, and that in drawings with fine detail, it is absolutely necessary to use a hard pencil so as to be able to draw very fine lines. This may be true in extreme instances, but as a rule it is possible to make such drawings to a larger scale so as to avoid the necessity for such lines. At any rate, drawings in which extremely fine lines are necessary are not made constantly, and softer pencils than, for example, 6-H could be used to advantage for everyday work.

A drawing with very fine lines may look neat to the casual observer, but the man who must work from it will appreciate bold, distinct lines, and as drawings are made for *use* and not for *appearance*, why not make them so as to best meet all practical requirements, and at the same time save the draftsman's eyesight? The latter incidental result is well worth accomplishing.

* * *

THE ENGINEERING OF ACCIDENT PREVENTION

Considerable misunderstanding seems to prevail on the question of accident prevention. It is looked upon by many as a purely humanitarian matter, and the general public appears to have the opinion that whenever an employer becomes imbued with the humanitarian spirit he merely has to spend a few dollars, or at least not an excessive sum of money, and say: "Henceforth we are going to prevent accidents in this factory." There is no question but that the initiative rests with the employer, and without his good-will and cooperation accident prevention is a difficult task; but apart from the efforts of the individual employer, the problem has vast ramifications. The prevention of accidents includes the solution of many difficult engineering problems. The designer both of machinery and of plant and general shop equipment needs training in order to understand the problems connected with accident prevention and to be able to guard against accidents in an effective manner. It seems safe to say that many accidents due to inherent dangers in machinery could be prevented *before* the machines are built. The time when they can be best guarded against—as has been repeatedly emphasized in MACHINERY—is when the design is on the drawing-board. The designer, the mechanical engineer, the superintendent of the plant—anyone responsible for the conditions under which men will operate machines or perform their duties—have a difficult task, and one that requires as careful attention as that of the purely operative features. The problem of accident prevention is essentially an engineering problem, and every machine designer should realize that the machine which is unsafe to operate is a failure, even if it should have 100 per cent efficiency. The plant in which men risk life and limb or health is not a well-designed plant, no matter how expeditiously the work passes through it.

* * *

THE PRINCIPLES OF GAGING

A common idea of a gage is that it is and should be an exact complement of the part to be produced in all essential details. A thread plug gage, for instance, is regarded as being properly a steel plug threaded and hardened, the thread shape being exactly that of a standard thread. A U. S. standard thread gage will be made with a thread section of sixty degrees included angle and with the top and bottom flattened one-eighth the pitch; a Whitworth gage with fifty-five degrees included angle and the top and bottom rounded.

The makers furnish gages in these forms in response to common demands, although they know well that a gage so made is not a properly designed testing instrument. It is true that the ordinary thread plug gage may answer for the purpose designed with general satisfaction and it is also true that it is hardly practicable to devise a low-priced gage in which the faults of the plug gage are eliminated. The plug gage satisfies the common demand for a standard form that can be referred to for all dimensions, angles and shapes. The mechanical public should recognize the fact, however, that a gage which measures all the dimensions of even a simple part, is likely to be a very poor instrument for testing its accuracy.

As a general principle, a plug should never be required to measure more than one diameter except in the case of tapers, and not even then where close limits are established. A solid gage should not be required to verify concentricity of more than two bored diameters simultaneously, nor should it be required to establish the truth of a tapered part with the axis of a bored hole by reference to any other part than the hole itself. Take the cartridge chamber of a rifle as an illustration. In this example, a chamber of peculiar shape is required to agree with master plugs and to be concentric in all cross-sections with the axis of the barrel. An amateur's idea of a proper gage would perhaps be a hardened steel plug fitting the chamber at all points and extending some distance into the barrel. Practically, such a gage is useless, for it covers so much that nothing is definitely determined within the limits prescribed by gun-makers.

The best type of gage and the one that is being adopted by progressive concerns whose work permits, is that in which fixed gage points are replaced by adjustable gage points fitted with micrometer dials so that the plus or minus readings can be taken. Gages of this style have been used for some time in the manufacture of sewing machines and guns. While costly to equip, they are correct in principle, and when intelligently used insure exact measurements and interchangeability.

MATHEMATICS FOR ENGINEERS

Engineering practice, both in design and operation, is based on our knowledge of physics and mathematics. The more exact and complete that knowledge, the less uncertain engineering results become, and hence the less the factor of safety or "factor of ignorance" as, aptly enough, it has been called. Too implicit a reliance on the conclusions of purely mathematical investigation has been a frequent fault in the past. The reams of baseless theory written on the gyroscope, the fall of the Quebec Bridge because a mathematical formula was stretched beyond its rightful limits, and the fact that, after more than seventy years of mathematical and physical theorizing, marine engineers are still unable to design a screw propeller which shall be fully efficient under novel conditions —all these are cases in point. While mathematical processes are essentially methods of precision, they give trustworthy results only when the basic assumptions from which they proceed are correct. Otherwise, like the house built on the sand, they fall before the winds and waves of practical experience.

In addressing the Mathematical Congress at Cambridge, England, in August, 1912, the late Sir William H. White, the foremost naval architect of his time, said:

> Purely mathematical theories have served, and still serve, a useful purpose in engineering; but it is now universally agreed that the chief services of mathematics in engineering are rendered in framing schemes for experimental research, in analyzing results, in directing the conduct of observations on the behavior of existing engineering works, and in the establishment of general principles and practical rules which engineers can utilize in their daily professional employment. * * * The mission of engineers as a class is to produce results, "to do things" which shall be of practical service to humanity and shall insure the safety of life and property. Complete solutions of problems, in the mathematical sense, are not usually to be found by engineers. They have to be content, in many cases, with partial solutions and fair approximations.

No argument is needed to prove that every young engineer—in college, in practice, or in the shops—should endeavor to acquire an adequate knowledge of mathematics. It is a mental tool which is in constant use in much of his daily work. Without it, even the approximate solution of difficult problems in untried fields would be impossible; and, in training the mind in logical and precise methods, it is invaluable. He finds, however, two obstacles to overcome: First, to decide just what, in his own case, this "adequate" knowledge comprises; and, second, how to gather this special knowledge, owing to the very general manner in which the whole subject is usually presented to him. Almost universally, engineering students are taught mathematics by mathematicians, and this practice has wide approval in that it gives a broader and more comprehensive view of the subject. There is, however, a marked difference between the engineer skilled in mathematics and the mathematician who has a general acquaintance with engineering work. In important respects, the two differ radically in their habit of thought. Mathematical methods are essentially rigid and precise; while, on the other hand, the determination of a stress to the nth place of decimals does not concern the engineer. In fact, any expenditure to obtain accuracy which is beyond "good enough" engineering requirements is a waste of time and money.

Hence, there seems much to support the argument often advanced that our technical schools should give supplementary courses in applied mathematics conducted by, and for, engineers. It is one thing to teach a student the general uses and handling of a file or a chisel, and quite another to show him, by concrete examples, the many things which can be accomplished with these tools. Such a course should exclude everything which is purely academic or is not required to meet the student's special needs, and it should show him, by varied and abundant examples from practice, the definite applications of mathematics in his special branch of engineering. Prof. John Perry, in his admirable work, "Calculus for Engineers," obviously had this need in view. A series of such books, covering the whole field of mathematics, would be of much service, not only to college students, but to practicing engineers and to that far greater body of eager and ambitious young men whose circumstances forbid technical training and enforce self-instruction.

THE 1912 U. S. STANDARD FOR FLANGED FITTINGS AND FLANGES*

The dimensions of the standard fittings and flanges adopted by the National Association of Master Steam and Hot Water Fitters and the American Society of Mechanical Engineers, are given, in part, in the Data Sheet Supplement accompanying this number. The tables in the Data Sheet cover the standard weight fittings from the 1-inch to the 26-inch size, whereas the 1912 U. S. standard includes standard weight fittings varying from 1 inch to 30 inches and extra-heavy fittings varying from 1 inch to 24 inches. The adoption of these schedules was the result of a long and careful investigation by the National Association of Master Steam and Hot Water Fitters' committee on standardization and a similar committee of the American Society of Mechanical Engineers.

The special feature of the 1912 U. S. standard is the interchangeability of fittings. For example, the face-to-face dimensions on the "run" of, say, 12-inch tees is the same whether the size be 12 by 2 or 12 by 12 inches. Crosses of corresponding diameter will also interchange with tees, the face-to-face dimension being standard. A cross or tee will also interchange with an elbow of the same nominal size. The advantages of this feature of interchangeability are obvious. In determining the dimensions and sizes, the aim of the committees was to provide for adequate strength, with the lowest cost consistent with uniformity. The various makes of flanges and fittings used heretofore have had such a low factor of safety as compared with the pipe itself, that it was deemed advisable to adopt a standard giving a higher factor of safety in the bolts, flanges and fittings.

The 1912 U. S. standard-weight flanges are identical with the alternative standard flanges submitted by the sub-committee of manufacturers with respect to diameter of bolt circle, number of bolts and diameter of bolt holes, with the exception that the U. S. standard gives ⅞ inch instead of ¾ inch for diameter of bolt hole for 4-inch pipe. The standard of the Engineering Standards Committee of Great Britain, and the standard of the *Verein deutscher Ingenieure*, do not have sizes exactly corresponding to the standard weight and extra-heavy weight of the 1912 U. S. standard, but have the most important dimensions the same for all pressures.

For extra-heavy flanges up to 9 inches inclusive, the 1912 U. S. standard and the standards of most manufacturers are identical. Above 9 inches the U. S. standard is somewhat larger than the present standards. With the British standard, the diameter of bolt circle and number of bolts are the same for pipes corresponding to the 1912 U. S. standard, or the proposed Manufacturers' standard weight and extra-heavy weight, but for sizes above 10 inches, the diameter of the bolt circle is from ¼ to ½ inch less than the proposed Manufacturers' standard and ¾ inch less than the U. S. standard. The number of bolts, in most cases, for pipes above 10 inches, in the U. S. 1912 and Manufacturers' is from two to four bolts greater than in the British standard. As far as size of bolts is concerned, the British standard makes a distinction between pipes for pressures up to 225 pounds and up to 325 pounds. The bolts for pipes up to 225 pounds, are below the Manufacturers' standard ⅛ inch in nearly every case, and below the U. S. standard from ⅛ to ⅜ inch. In pipes for a pressure of 325 pounds, the British standard is the same as the proposed Manufacturers' schedule in all cases except 14- and 18-inch sizes, in which cases the British standard is ⅛ inch larger than the Manufacturers' standard, but is from ⅛ to ¼ inch smaller than the U. S. standard.

It is thus seen that wherever there is a distinction between the 1912 U. S. and proposed Manufacturers' standard, the 1912 U. S. standard is invariably on the side of greater safety and strength and has the added feature of interchangeability, whereas the proposed Manufacturers' schedule has different face-to-face dimensions. As to the comparison with the British and German standards, it must be remembered that they cover, by one standard, both weights of the American specifications, and naturally, as would be expected with compromises, must have higher values for standard-weight pipes and lower values for extra-heavy weight pipes.

* With Data Sheet Supplement.

DESIGNING FACEPLATE JAWS AND SCREWS FOR A HEAVY LATHE

AN ANALYSIS OF STRESSES AND DETERMINATION OF DIMENSIONS TO RESIST THEM

BY W. G. DUNKLEY*

There are some cases in the design of machine tools where the determination of the strength of different parts by rigid calculations is practically impossible, owing to the uncertain nature of the stresses involved. In other cases, such calculations would probably be unnecessary, because the designer might safely rely upon his experience to guide him in proportioning the parts correctly. In designing the jaws and screws for the faceplate of a heavy lathe, however, it is both possible and necessary to determine the limiting sizes by direct calculation. A lathe which is required for heavy faceplate operations may be severely handicapped, simply because its faceplate cannot carry work which might otherwise be handled in the lathe. The greatest difficulty which confronts the designer in work of this kind is that he does not always know the actual load that the machine members may be called upon to carry; in such cases, the approximate load can only be determined by supposition.

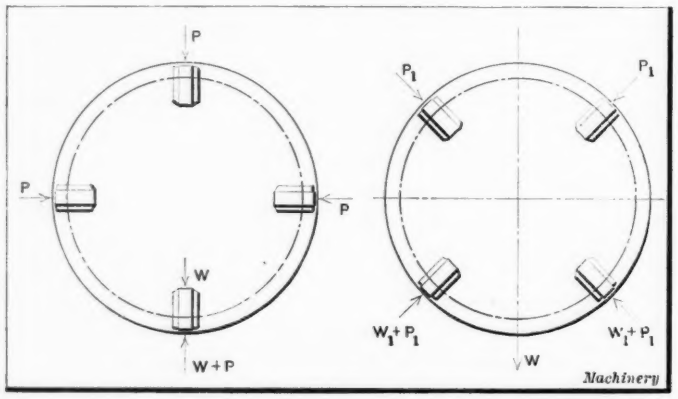

Fig. 1. Pressure on Jaws with Screws Vertical and Horizontal

Fig. 2. Pressure on Jaws with Screws inclined 45 Degrees

In the design of the jaws and screws for the lathe faceplate dealt with in the present article, the writer has selected a case in which the work is 12 feet in diameter by 3½ feet long and weighs 80 tons. The first point to be considered is the equilibrium of the load when held stationary in the position shown in Fig. 1. There is obviously a tendency for the load to rotate about the point *O*, Fig. 3. In order to fall from the faceplate, it would be necessary for the work to shear off the corner of the top jaw at *N;* but since the distance O–N_1 is very little greater than the distance O–N, this will not be necessary if the jaw does not fit well on the work, as indicated by the dotted lines. On this account, it is safer for purposes of calculation to consider that the work is prevented from falling over by the frictional resistance due to the pressure of the three upper jaws. The two side jaws may possibly relieve the lower jaw of a part of the load, but here again it is safer to assume that the lower jaw takes the total downward force due to the weight of the work. If the work is of the shape indicated by the dotted line at the lower jaw, the pressure on this jaw will be concentrated at the point *O*, and we will consider that this is the case, in order that the extreme condition of stress may be dealt with.

The Maximum Pressure on the Lower Jaw

Referring to Fig. 3, let P be the necessary pressure on each jaw to give the required frictional resistance to prevent the work from falling over. If μ is the coefficient of friction, μP is the frictional resistance offered by each jaw to prevent the work from falling over. Taking moments about *O* we get:

$$144\,\mu P + 2 \times 72\,\mu P = 80 \times 16 \text{ inch-tons.}$$

$$288\,\mu P = 80 \times 16 \text{ inch-tons.}$$

Assuming $\mu = 0.2$, we get

$$P = \frac{80 \times 16}{288 \times 0.2} = 22 \text{ tons (approximately.)}$$

Perhaps it should be mentioned at this point that the pressure of the jaws on the work would really be somewhat greater than the result obtained by the preceding calculation, in order to hold the work when the faceplate is in the position shown in Fig. 2. The value of P, however, is undoubtedly greater than it actually needs to be, because the fact that the jaws are serrated has been neglected. This serration of the jaws will enable them to bite into the work to some extent, the result being more than sufficient to adequately insure the ability of the faceplate to hold the work.

Referring to Figs. 1 and 3, it will be seen that allowance must be made for a total vertical pressure of $W + P$ tons on the lower jaw. We have assumed that this pressure is concentrated at the point *O*, its amount being given by the following equation:

$$W + P = 80 + 22 = 102 \text{ tons.}$$

Determining the Depth of the Lip

The lip of the jaw $AOBA_2$ in Fig. 4 is a cantilever loaded with $W + P = 102$ tons at the end, and having a length of 5 inches. Therefore, the stresses across the section A–A_2 consist of a shearing stress varying from zero at A and A_2 to a maximum at A_1,* and also of tensile and compressive stresses of varying intensity, the latter being due to the bending moment of the load which is:

$$M = 102 \times 5 \text{ inch-tons.}$$

It will be evident that the stresses across this section are of variable intensity. Without entering into a complete discussion of this matter, we will deal with the tensile stress at the point *A;* this is the point of maximum tensile stress in the section and so may safely be used as a basis of calculation.

Let f_t = safe tensile stress = 6 tons per square inch;

$$Z = \text{modulus of section} = \frac{b \times H^2}{6};$$

M = maximum bending moment in inch-tons.

Then $f_t Z = M$ inch-tons.

Substituting known values in this equation, we have:

$$\frac{6 \times 8H^2}{6} = M = 102 \times 5 \text{ inch-tons.}$$

$$H^2 = \frac{102 \times 5 \times 6}{6 \times 8} = 63.7.$$

$$H = \sqrt{63.7} = 8 \text{ inches (approximately.)}$$

If we consider that the load is not concentrated at *O*, but that it is equally distributed along A–O, the value of the bending moment will be:

$$M = 102 \times \frac{5}{2}$$

$$H^2 = \frac{102 \times 5 \times 6}{2 \times 6 \times 8} = 31.8$$

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[* The common theory of flexure is a convenient assumption for practical purposes, and assumes that the internal stresses at any transverse section of a loaded beam are resolved into horizontal components producing longitudinal tension or compression, and vertical components producing vertical shear. The stress due to this shear is assumed to be of uniform intensity over the transverse section of the beam. This common theory of flexure, therefore, disregards the horizontal shear in the beam due to bending. Assume, for example, that a wooden beam 12 by 12 inches and of any convenient length is supported at both ends with a load in the middle; it will then bend a certain amount. Then take a pile of boards, each board being 12 by 1 inch and of the same length as the beam. Stack these boards to form a beam 12 by 12 inches and support and load them in the same way the beam was loaded. According to the common theory of flexure, both these beams have equal resistance to bending, but it will be found that the composite beam will bend considerably more than the solid beam. The reason is that in the solid beam there is a resisting horizontal shearing stress which opposes bending. This is absent in the composite beam, because the boards are free to slide on each other. The true shearing stress, therefore, is different from that assumed by the common theory of flexure. When the horizontal shearing stress is considered, the intensity of the resulting shearing stress varies from zero at the lower and upper surfaces of the beam to a maximum at the neutral surface. The common theory of flexure, however, in neglecting the horizontal shear generally errs on the side of safety. It is, in general, unnecessary to consider the horizontal shear, but the author of the present article has undoubtedly called attention to the varying stresses due to shearing, in order to make clear the difficulty of an exact theoretical analysis and to show how the calculations can be carried out to satisfaction, even when the complex nature of the stresses is disregarded.—EDITOR.]

$H = \sqrt{31.8} = 5.65$ inches

An approximate value of H lying between the two values determined by the preceding calculations is 7 inches, and this would probably represent a safe figure for practical purposes. Considering the fairly high safe stress of six tons per square inch that was assumed, however, it will probably be wiser to accept the first value of $H = 8$ inches in order to make allowance for heavier work that may be set up in the lathe. It is important to note that if the value of H had been determined by simply considering the shearing stress on the

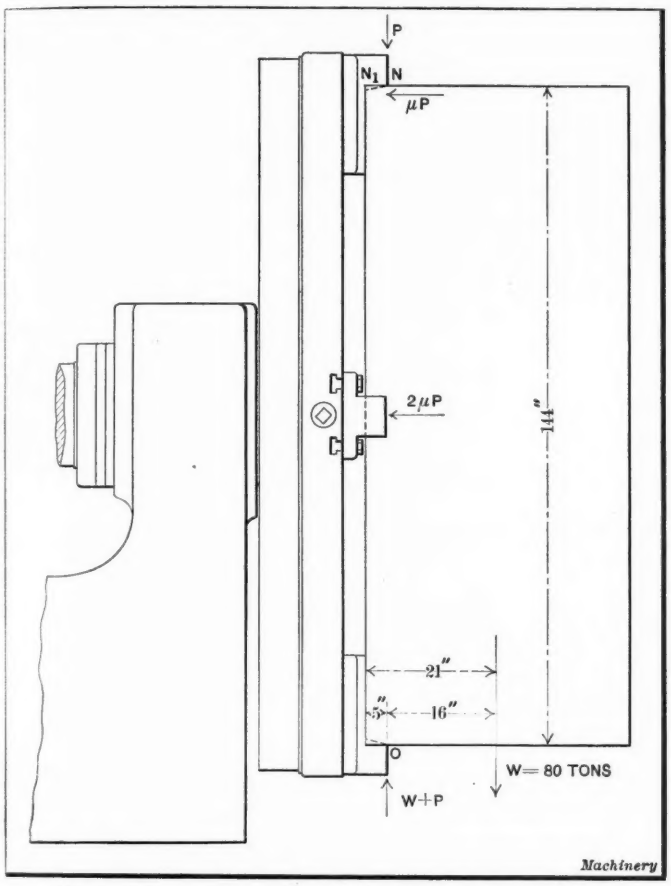

Fig. 3. Stresses produced by Weight of Work on Faceplate Jaws

section A-A_2—a shearing stress of 5 tons per square inch being used—the value of H would have been as follows:

$5 \times \text{area} = \text{total shearing stress} = 102$ tons

$5 \times 8H = 102$ tons

$$H = \frac{102}{40} = 2.55 \text{ inches}$$

It will be obvious from a comparison of this value with the values obtained in the preceding calculations, that the result obtained from a simple consideration of shearing stresses is entirely inadequate; and that it is essential to consider both the bending and shearing stresses in designing this member.

The Size of the Bolts in the Jaws

The forces which hold the lower jaw in equilibrium are shown in Fig. 4, where the vertical downward pressure on the jaw of $W + P$ tons is balanced by the vertical reaction R of the screw, by the friction between the jaw and faceplate, and by the friction between the T-nuts and T-grooves. If T is the tension in tons per bolt, the frictional resistance caused by the eight bolts will be as follows:

$8\mu T$ = frictional resistance between jaws and faceplate.

$8\mu T$ = frictional resistance between T-nuts and T-grooves.

Assuming a value of 0.2 for the coefficient of friction μ, we have the total of the frictional resistances as follows:

Total frictional resistance $= 16 \times 0.2\,T = 3.2\,T$ tons. To preserve equilibrium, the total upward forces must balance the total downward forces and so we have:

$$R + 3.2\,T = 102 \text{ tons} \qquad (1)$$

Taking moments about C, we get

$$RX + 102\,Y = 2 \times 4\,T + 2 \times 10\,T + 2 \times 16\,T + 2 \times 22\,T$$

$$RX + 102\,Y = 104\,T$$

In the preceding calculations, the value of the frictional resistances between the T-nuts and T-grooves of the jaws have been neglected as their value is relatively small. Giving X a value of 4 inches and Y a value of 10 inches, we get

$$4R + 1020 = 104\,T \qquad (2)$$

In order to solve these two equations to determine the values of R and T, we multiply Equation (1) by 4 which gives

$$4R - 408 = -12.8\,T$$

Subtracting this result from Equation (2) gives

$$1428 = 116.8\,T$$

$$T = \frac{1428}{116.8} = 12.2 \text{ tons per bolt}$$

Substituting this value of T in Equation (1) we get

$R = 102 - 3.2 \times 12.2 = 63$ tons.

We see from this result that when bolts are tightened up sufficiently to prevent the work from slipping, the frictional resistance will take 39 tons of the vertical downward load of 102 tons, leaving the screw to carry the remaining 63 tons. Assuming the safe stress on the bolts to be 3 tons per square inch, we have

$3A$ = tension per bolt = 12.2 tons.

This gives the value of A—the cross-sectional area of the bolts—as follows:

$$A = \frac{12.2}{3} = 4.06 \text{ square inches}$$

$$D^2 = 4 \times \frac{4.06}{\pi}$$

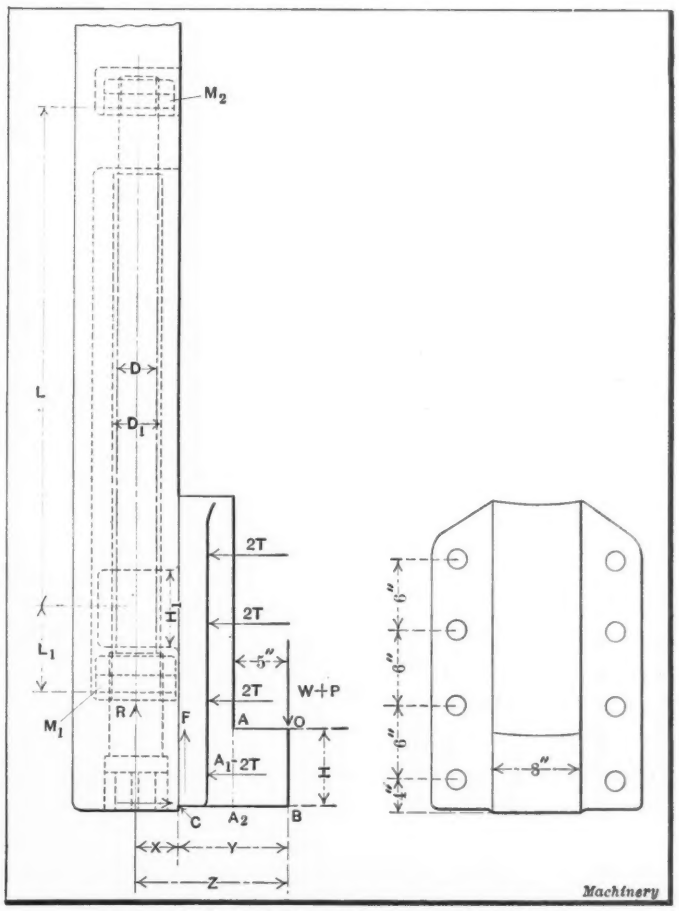

Fig. 4. Analysis of Stresses in Lower Jaw and Screw

$$D = \sqrt{4 \times \frac{4.06}{\pi}} = 2.25 \text{ inches (approximately)}$$

It is, of course, impossible to know with what intensity the bolts will be tightened up, and for this reason the safe tensile stress has been taken at the very low figure of 3 tons per square inch, in order to allow for excessive tightening.

The Adjusting Screws

The design of the adjusting screws is an extremely important part of the faceplate design, as it is evident that these screws are called upon to carry a very considerable load. We

have already seen that the maximum load on each screw is 63 tons. Assuming a safe stress of 5 tons per square inch, we have:

$$5A = 63 \text{ tons}$$

$$A = \frac{63}{5} = 12.6 \text{ square inches}$$

$$D^2 = 4 \times \frac{12.6}{\pi}$$

$$D = \sqrt{4 \times \frac{12.6}{\pi}} = 4.0 \text{ inches.}$$

We come now to the question of whether the lock-nuts should be put at M_1 or M_2 in Fig. 4. If the lock-nuts are placed at M_2, the screw is in tension while if they are placed at M_1, the screw is under compression. It is one of the universally accepted maxims of good designing that screws should always be put under tension if possible and at first sight this would appear to decide the question at once. It is undesirable for long screws to be put in compression, owing to the tendency which exists for them to give way laterally; we must not forget, however, that this rule does not hold for short screw lengths in compression. We already know that the adjusting screws of the lathe faceplate under consideration, may be stressed to 5 tons per square inch, and in deciding the correct position of the lock-nuts, the fundamental relations between stress and strain must be borne in mind. These relations may be briefly outlined as follows:

Stress per square inch = strain × modulus of elasticity.

$$\text{Strain} = \frac{\text{Extension (or compression)}}{\text{Original length under stress}}$$

$$\text{Stress per square inch} = \frac{\text{Extension (or compression)}}{\text{Length under stress}} \times E$$

Extension (or compression) = (Stress per square inch × Length under stress) ÷ E

In the preceding relations, E is the modulus of elasticity = 13,000 tons. We see that although the strain depends entirely upon the stress, the actual extension or compression due to this stress, is proportional to the length of the screw under stress. This holds good for both tension and compression. If the lock-nuts are placed at M_2, $L = 50$ inches = length of screw and this gives:

$$\frac{5L}{E} = \text{extension of screw} = \frac{5 \times 50}{13{,}000} = 0.019 \text{ inch.}$$

If the lock-nuts are placed at M_1, the length of screw under stress is $L_1 = 7$ inches, which gives the amount of compression as

$$\frac{5L_1}{E} = \frac{5 \times 7}{13{,}000} = 0.003 \text{ inch.}$$

The results of the preceding calculations show that the best design is that in which the lock-nuts are placed at M_1, because the change of length in the screw in this case is only about one-seventh of what it would be if the lock-nuts were placed at M_2. If the screws had been made smaller, the stress would probably be considerably greater than 5 tons per square inch and with the lock-nuts placed at M_2, the extension of the screw would become very appreciable. Now let us consider what this might mean. With the load as shown in Fig. 3, the stress in the lower screw is considerably greater than in the upper screws. The extension of the lower screw, due to this stress, will reduce the grip of the upper jaw so that the grip of the two side jaws is largely responsible for holding the work in position. The reduction of the grip of the upper jaw produced in this way, may be sufficient to allow the work to fall from the chuck in extreme cases, where the size of the screws has been reduced—with a false view to economy—so that they are too small to carry the load without undue elongation. This point has been mentioned to emphasize the importance of designing the screws in such a way that the elongation will be reduced to a minimum. When the lock-nuts are placed at M_1, and the jaws are moved nearly to the center, there will necessarily be a greater length of screw under compression; but as the jaws are moved toward the center of the chuck, the size and weight of the work which they carry is reduced, the tendency toward increased compression being limited in this way.

The Length of the Nut

In determining the proper length H_1 for the nut, a width of seven inches will be assumed. The value of the bending moments taken about the point C is given by the following equation:

$$f_t Z = \text{Bending moments} = R X = 63 \times 4 \text{ inch-tons.}$$

$$Z = \frac{63 \times 4}{f_t} = \frac{63 \times 4}{6} = 42.$$

For the rectangular section in question,

$$Z = \frac{b H_1^2}{6} = \frac{7 H_1^2}{6}$$

Substituting known values in this equation, we have

$$H_1^2 = \frac{6 \times 42}{7} = 36$$

$$H_1 = 6 \text{ inches}$$

which is the required length of the nut.

* * *

OPTICAL ILLUSIONS

The accompanying illustrations show some optical illusions of a very interesting character. The illustrations and the captions beneath them are self-explanatory. Those shown in

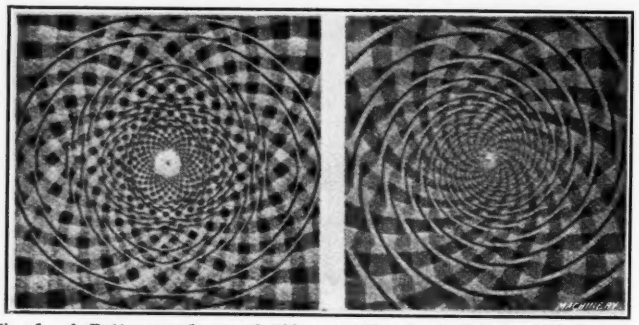

Fig. 1. A Pattern made up of Oblongs? No; Concentric Circles!

Fig. 2. A Spiral which is not a Spiral. What is it?

Figs. 1 and 2 are of exceptional interest. It is almost impossible to convince oneself that the lines drawn around the center

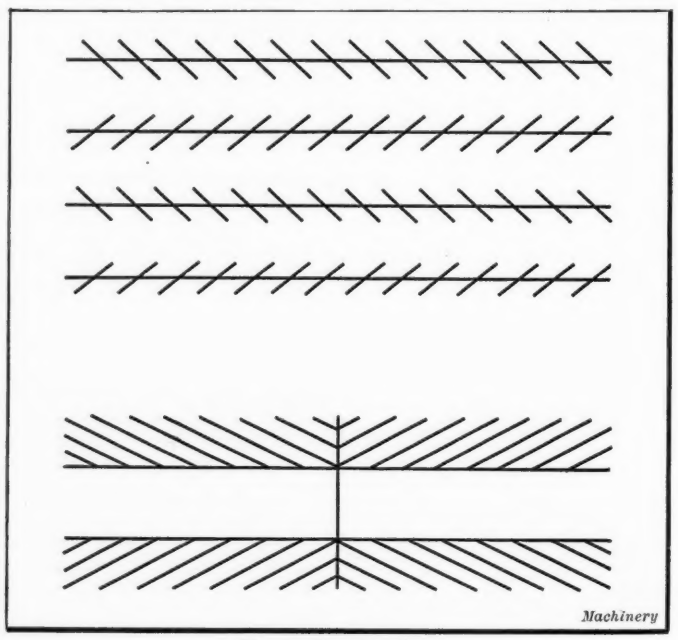

Fig. 3. Parallel Lines

in Fig. 1 are concentric circles. Try with a compass, however, and the lines that look like hoops sadly bent into all kinds of shapes will be found to be "round circles."

* * *

During 1912, 3000 miles of new line was added to the railroads of the United States.

POWER REQUIREMENTS FOR MACHINE TOOLS

SUMMARY OF TESTS MADE TO DETERMINE POWER CONSUMPTION OF MACHINE TOOLS

BY HARRY C. SPILLMAN*

A few years ago the electric motor drive began to take a prominent place in manufacturing plants. At that time many factories changed from the old method of belting the engine

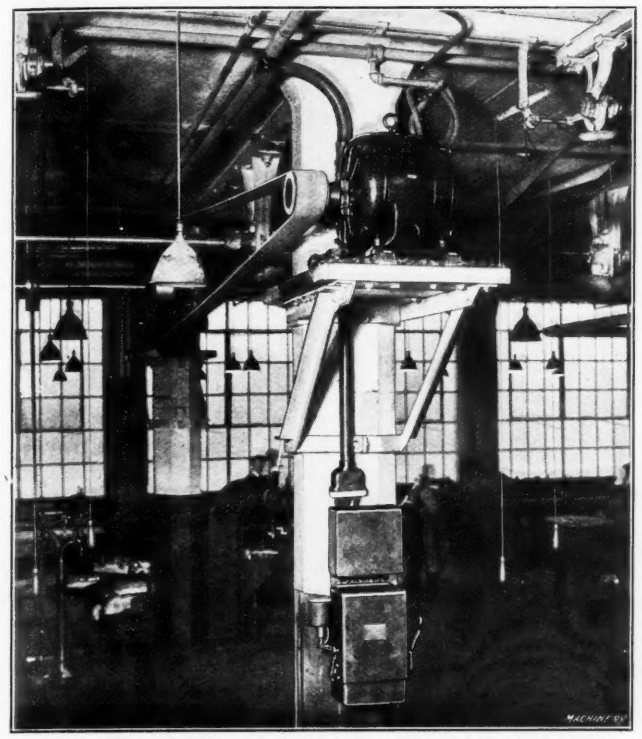

Fig. 1. View of Motor and Bracket Mounted on Concrete Column

to a large drive shaft, which was connected by belts to long lines of shafting throughout the plant, to the individual motor drive having a separate motor attached to each machine. The owners soon discovered that this made a very expensive installation, and this form of drive, although the most flexible, is gradually giving way to the group drive for light machine shop work. In the group drive a motor drives a short length of lineshafting which, in turn, drives the machine tools. This arrangement makes the first cost considerably less than that of the individual motor drive, and if planned systematically it is almost as flexible as the latter method.

The best arrangement for the group drive is to divide the machine shop into small units, having a motor for each department or each kind of machines. The lineshafting should be as short as possible and the motors placed in accessible positions, so that they can be watched and easily replaced in case of a breakdown. A small platform makes an excellent mounting for a motor, as it can be easily inspected and removed if found necessary. Experience has proved that motors suspended from the ceiling do not receive as careful attention, and a further disadvantage of this method of mounting lies in the fact that the motors are difficult to replace when set up in this way. With the proper equipment, a motor can be removed from a platform and a new motor installed in less than fifteen minutes. By carefully planning a group drive system, all the lineshafting can be run at the same speed and a standard size motor adopted for the entire shop. This does away with the necessity of carrying a number of different sized motors in stock and standardizes the motor equipment of a factory.

Construction engineers are unable to obtain reliable data for figuring the proper size of motors to drive machine tools. During the installation of mechanical equipment in an automobile engine factory, the machine shop was carefully laid out and a copy of the drawing, together with the sizes of machine tools, kind of work, speed and other technical information were sent to the different machine tool builders with the request that they give the exact power requirements for their machines when operating on the group drive system. The replies were carefully tabulated and after a careful analysis, it was shown that machine tool builders were giving the same results for group drive as for the individual drive, overlooking the fact that some of the machines would be idle and others consuming only a small amount of power at the time when the remaining machines were absorbing the maximum amount of power. These conditions all tend to equalize one another, so that the average power used by each machine would be considerably less for the group drive than the maximum power demanded for the individual drive.

Careful tests which have been made since the machine shop was placed in operation show that the shop takes less than one-fifth of the power recommended by the machine tool builders, or in other words, they were figuring over five times too high for the group drive. The machine shop where these tests were made has been in operation about nine months. The men work on a premium system; all work is laid out in the planning room, and the machines are carefully watched to see that they are operating at the proper speed. Time studies are also made at intervals, and to further increase the efficiency of the machines, expensive and cleverly designed jigs are used so that the work can be very quickly and accurately set up.

POWER REQUIREMENTS OF MACHINE TOOLS

Kind of Machine	Kind of Work	Per Cent of Machines Running	Floor Area for Machine and Operator in Square Feet	Total Average Power Per Machine in Watts*	Total Average Power Per Machine in Watts†	Friction and Lineshaft Load Per Machine in Watts†	Average Power Used in Doing Actual Work, in Watts*	Total Power Per Square Foot of Floor Area, in Watts
No. 2 Horizontal Rockford Boring Mills	Boring Bearings in Aluminum Cases	85	150	1620	1320	1100	300	8.8
No. 4 Cincinnati Millers	Light Milling on Aluminum	100	120	995	995	830	500	8.3
16-inch Lodge & Shipley Lathes	Turning Small Forgings	60	55	900	555	500	87	10.1
Double Disk Grinders; Double Buffers; Two Wheel Emery Stands	Grinding and Polishing	55	55	1800	1000	300	830	18.2
24-inch Bullard Vertical Lathes	Heavy Cuts on Cast Iron Flywheels	100	100	1350	1350	350	1000	13.5
24-inch Gould & Eberhardt Gear Cutters	Cutting Small Cast Iron Gears	100	65	333	333	250	83	5.1
Four Head Ingersoll Milling Machines	Making Four Cuts on Cast Iron Cylinders	100	300	3550	3550	2300	1250	11.8
Baker Single and Bausch Multi-Spindle Drills	Drilling and Tapping Cast Iron	40	70	1530	637	550	217	9.1
Heald Grinders, No. 60 Internal Grinders ‡	Cylinder Grinding	85	70	2830	2430	1860	500	34.7
No. 6 Whitney Hand Millers	Keyseating Small Cast Iron Gears	60	40	365	220	120	165	5.5
Landis No. 2 Grinders	Grinding Cam Shafts	80	90	1875	1500	1000	625	16.7
Norton 10 by 50-inch Grinders	Grinding Pistons and Small Forgings	70	100	2000	1400	1100	450	14
Jones & Lamson Flat Turret Lathes	Machining Small Forgings	85	65	675	560	200	375	8.6
Eight Spindle Cincinnati Gang Drills	Drilling and Reaming Connecting Rods (8 holes)	100	110	2840	2840	2000	840	25.8
Potter & Johnston Automatics	Turning Small Cast Iron Gears	100	75	690	690	440	250	9.2
1⅜-inch Gridley Automatics	Machining Cast Iron Pistons	100	200	1520	1520	1250	270	7.6
No. 4 Warner & Swasey Turret Lathe	Machining Small Forgings	65	55	560	360	310	70	6.5
24-inch Cincinnati Drill Presses	Small Drilling on Forgings	90	40	520	474	345	100	11.8

Machinery

* Deducting Idle Machines. † Including Idle Machines. ‡ Exhaust Fan not considered.

* Address: 1537 Second Ave., Detroit, Mich.

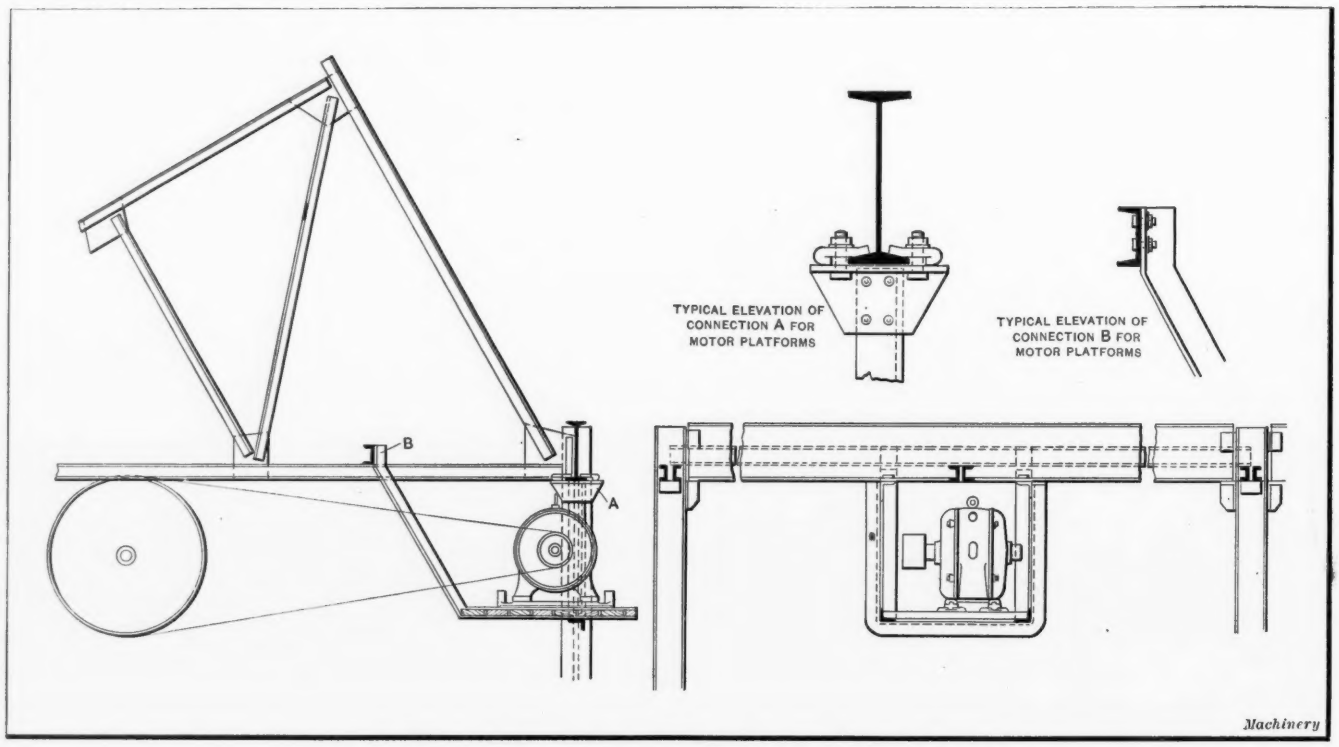

Fig. 2. Design of Motor Platform for Use in Buildings with Saw-tooth Roof

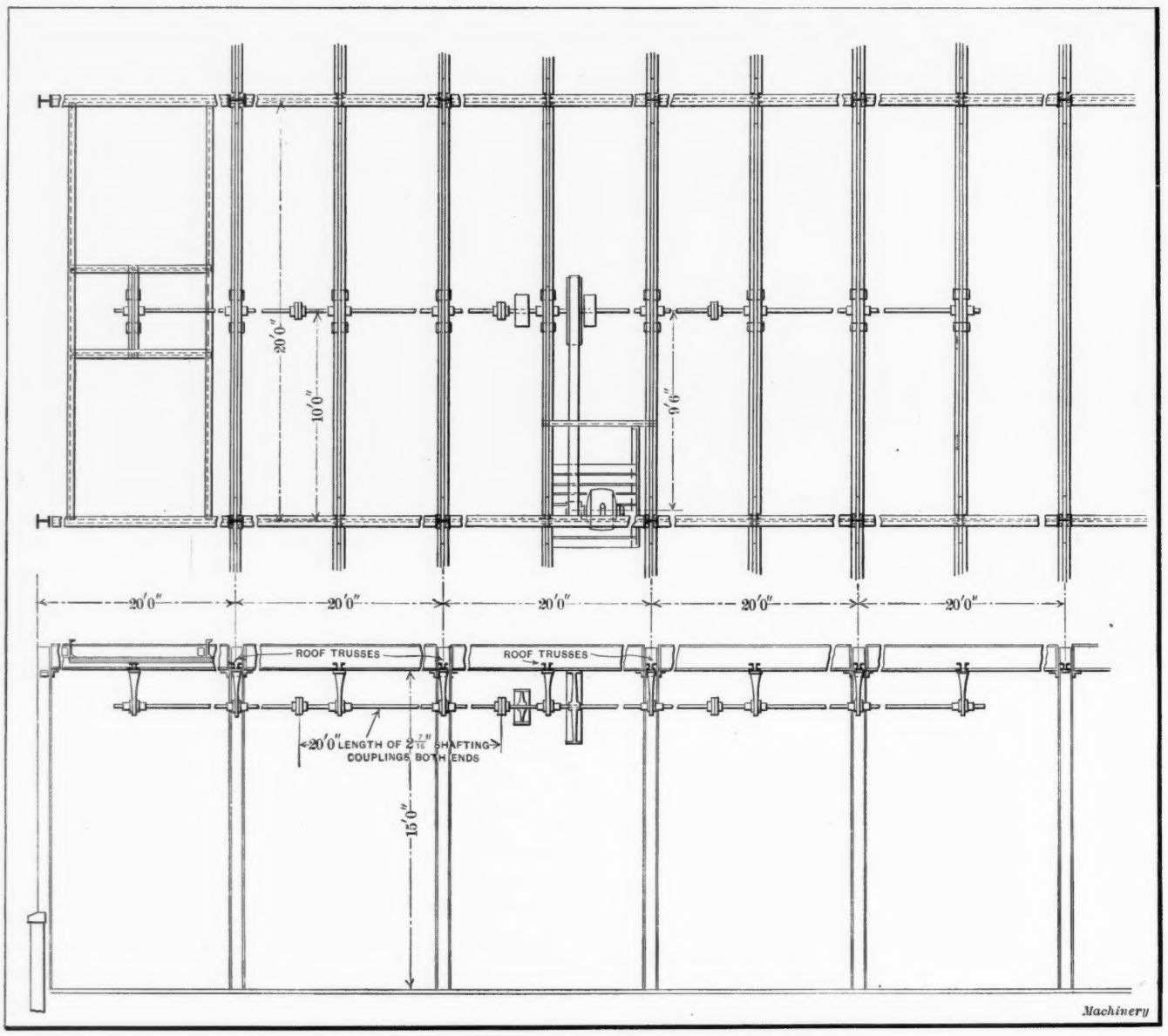

Fig. 3. Layout of Transmission System for Building with Saw-tooth Roof

The transmission equipment consists of a 20-horsepower motor for each department, mounted on a platform and driving two or three short lengths of lineshafting, each about seventy feet long. The shafting is 2 7/16 inches diameter, running at 240 revolutions per minute, and supported on Hyatt roller bearings in Wood type frames at intervals of ten feet. The frames have an 18- to 20-inch drop and are fastened directly to the steel work; the shafting was carefully lined up when installed and re-checked with a surveyor's level. Split cast-iron pulleys are used throughout the factory and special attention has been given to length of belt drives. The equipment is kept in excellent condition and not a single replacement has taken place for shafting, belting or pulleys.

In making the power tests, every precaution was taken to avoid errors. The motors were all tested for their efficiency at different loads and the electrical instruments were carefully calibrated. Readings were taken when the motor was driving the line and countershafts only, no machines being in operation. The electrical losses were deducted, which gave the net shafting and countershafting loss, and this was carefully proportioned among the different machines. The second reading was taken with the machines running light, which gave the total friction loss. After these tests were completed, the machines were put into operation and readings were taken every fifteen minutes. A record was also made of the number of machines in operation and the kind of work the machines were doing. Each motor in this factory drives only one kind of machine tools, which greatly assisted in obtaining accurate results for the amount of power consumed by each size and kind of machine. These data were carefully tabulated and the floor area occupied by each machine, and space allotted for the operator were noted; also the total length of lineshafting. The trucking aisles and all other space not used for manufacturing was deducted, so that the unit values per square foot of floor area include the machine and sufficient space for the operator and material. As a final re-check for accuracy, the total power utilized by the machine shop taken from these different tests was compared with the total power used by the machine shop as shown at the switchboard at the power house. These two figures checked within two per cent, and this was allowed for transmission losses between the motors and the power house.

Builders of transmission equipment have very little data showing friction losses with different kinds of bearings for lineshafting taken under actual working conditions. These results show that the lineshafting and countershafting consume thirty per cent of the total power, and the total friction losses absorb seventy-two per cent of the total power. This makes a forty-two per cent loss of power from the countershafting to the machine tools, and only twenty per cent of the total power is utilized in doing work. The electrical loss shows eight per cent of the total power. In the table there are two items mentioned as follows: Total average power per machine, deducting idle machines; total average power per machine, including idle machines. These items include all the mechanical power of that department, such as lineshafting, countershafting, machine friction and power consumed in doing work on the machines. In the first case this total power is equally divided among all the machines which are in operation. In the second case it is divided equally among all the machines, both running and idle. The electrical losses are omitted in all cases.

Fig. 4. General View of Tool-room showing Method of supporting Shafting on Concrete Ceiling

* * *

According to a bulletin of the United States Bureau of Education, an arrangement has been made between the school authorities and the Illinois Central Railroad Co. at McComb City, Miss., whereby high-school boys may work every other day in the railroad shops and on alternate days attend the high school. The boys receive a minimum wage of twelve cents an hour. It is stated that as an educational experiment this plan has proved successful so far.

CALCULATIONS AND DATA FOR SQUARE MILLING OPERATIONS

BY GEORGE W. BURLEY*

In order to be able to mill squares accurately on the ends of the shanks of such tools as taps and reamers, and on the ends of machine feed-screws, without having recourse to any cut-and-try method, it is necessary to know three dimensions; these are the distance between opposite flats or sides of the square, the diameter of the shank or screw end which corresponds to this distance, and the depth of the cut required from the circumference of the circle to the side of the square. The first dimension is generally the one upon which the other two

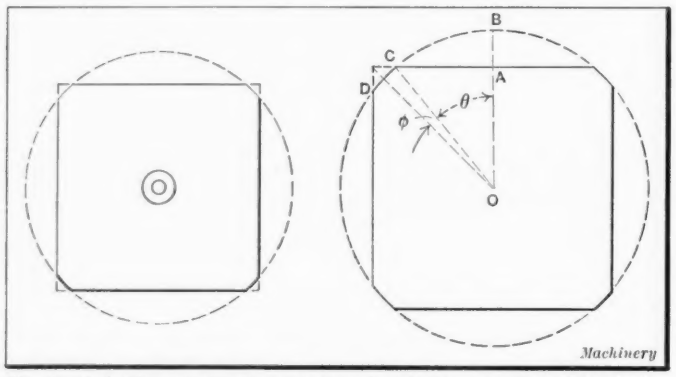

Fig. 1. End View of the Squared End of a Tap Shank

Fig. 2. Diagram showing Method of Making Calculations

are based. It is usually selected to agree with the general dimensions of the tap, reamer, or screw; and, in the case of taps, to suit standard wrenches. From this dimension the other two can be calculated, as shown by the following discussion.

Usually, the square is formed without sharp corners, there being a small part of the original curved surface left on at what should be the corner of the square, as is indicated in Fig. 1. As a result of this practice the diameter of the required circle cannot be taken as equal to the diagonal of the square, as would be the case if it had square corners. The exact diameter in each case is dependent upon the ratio of the width of the land to the width of the square. The conditions which are involved in the determination of the values of the diameter and the depth of cut are indicated in Fig. 2. In this figure, OA represents one-half of the distance between the opposite sides of the square; OB, OC, and OD represent the radii of the circle; and CD represents the part of the original curved surface left on the squared section. Now, from this figure, we see that:

TABLE OF DIAMETERS AND DEPTHS OF CUT

Width of Square Z	Diameter D	Depth of Cut d	Width of Square Z	Diameter D	Depth of Cut d
$\frac{1}{16}$	0 0819	0.0097	$1\frac{9}{16}$	2.0471	0.2425
$\frac{1}{8}$	0.1638	0.0194	$1\frac{5}{8}$	2.1294	0.2522
$\frac{3}{16}$	0.2457	0.0291	$1\frac{11}{16}$	2.2109	0.2619
$\frac{1}{4}$	0.3275	0.0388	$1\frac{3}{4}$	2.2932	0.2716
$\frac{5}{16}$	0.4095	0.0485	$1\frac{13}{16}$	2.3747	0.2812
$\frac{3}{8}$	0.4914	0.0582	$1\frac{7}{8}$	2.4566	0.2908
$\frac{7}{16}$	0.5733	0.0679	$1\frac{15}{16}$	2.5383	0.3004
$\frac{1}{2}$	0.6550	0.0775	2	2 6200	0.3100
$\frac{9}{16}$	0.7371	0.0873	$2\frac{1}{16}$	2.7021	0.3198
$\frac{5}{8}$	0.8190	0.0970	$2\frac{1}{8}$	2.7842	0.3296
$\frac{11}{16}$	0.9009	0.1067	$2\frac{3}{16}$	2.8660	0.3394
$\frac{3}{4}$	0.9828	0.1164	$2\frac{1}{4}$	2.9484	0.3492
$\frac{13}{16}$	1.0647	0.1261	$2\frac{5}{16}$	3.0303	0.3589
$\frac{7}{8}$	1.1466	0.1358	$2\frac{3}{8}$	3.1122	0.3686
$\frac{15}{16}$	1.2283	0.1454	$2\frac{7}{16}$	3.1936	0.3783
1	1.3100	0.1550	$2\frac{1}{2}$	3.2750	0.3880
$1\frac{1}{16}$	1.3921	0.1648	$2\frac{9}{16}$	3.3570	0.3977
$1\frac{1}{8}$	1.4742	0.1746	$2\frac{5}{8}$	3.4390	0.4074
$1\frac{3}{16}$	1.5561	0.1843	$2\frac{11}{16}$	3.5207	0.4171
$1\frac{1}{4}$	1.6380	0.1940	$2\frac{3}{4}$	3.6025	0.4268
$1\frac{5}{16}$	1.7199	0.2037	$2\frac{13}{16}$	3.6843	0.4365
$1\frac{3}{8}$	1.8018	0.2134	$2\frac{7}{8}$	3.7662	0.4462
$1\frac{7}{16}$	1.8837	0.2231	$2\frac{15}{16}$	3.8481	0.4556
$1\frac{1}{2}$	1.9656	0.2328	3	3.9300	0.4650

Machinery

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$$R = OC = \frac{OA}{\cos AOC} = \frac{OA}{\cos \theta}$$

where $\theta = (45 - \phi)$, ϕ being the angle at the center of the circle which is subtended by one-half of the arc CD. The value of ϕ is, therefore, $\frac{CD}{2R}$ radians or $\frac{CD}{R} \times 28.65$ degrees.

From an examination of a large number of cases it appears that the average value of the ratio $\frac{CD}{R}$ is $\frac{1}{6}$, in which case

$\phi = 4$ degrees 46.5 minutes

$\theta = 45 - \phi = 40$ degrees 13.5 minutes.

Therefore:

$$R = \frac{OA}{\cos 40^\circ 13.5'} = \frac{OA}{0.7635} = 1.310 \times OA$$

and $D = 2.620 \times OA = 1.310Z$

where Z = the whole width of the square.

The depth of the cut d is represented by the length of the line AB and has a value of:

$$d = \frac{D - Z}{2} = \frac{1.310 - 1}{2} \times Z = 0.155Z.$$

By means of these two expressions the diameter and the depth of cut for any given case can be calculated; but to facilitate matters, the values of D and d have been calculated by the writer for a large number of values of Z between 1/16 inch and 3 inches, and these have been embodied in the table which can, therefore, be used directly for the purpose of obtaining the values of these two quantities.

* * *

DEVELOPMENT IN THE PLANING ART

The production of true flat surfaces has been accomplished on the planer since about 1835, but when very accurately fitting parts were desired, the surfaces in contact were generally finished by scraping. This operation done by hand is slow and expensive, and is one that progressive manufacturers have endeavored to eliminate as much as possible. Scraping all sliding flat surfaces was done by the greater number of machine tool builders up to the time when high-speed steel came into use, when planer manufacturers along with other machine tool builders found it necessary to redesign their tools to meet the new demands which this improvement in steel brought about.

A trained operator with a modern high-speed planer can produce true planed surfaces requiring very little scraping. In fact, some manufacturers of accurate and high-grade machine tools dispense with the use of the scraper almost entirely. To obtain these results it is necessary that the work be properly clamped, and cutting tools of the correct shape be used. The work should be rigidly clamped for the roughing cut, care being taken not to spring it out of shape, and using a round nose roughing tool on cast iron. The clamps should then be released slightly and a lighter cut taken.

After taking a roughing cut some manufacturers follow the practice of taking the work off the planer and allowing it to season for some time. Then it is put back on the planer, clamped lightly, and a light cut taken across the entire surface. The clamps are now released until they exert just sufficient pressure to prevent the work from lifting, the thrust of the cutting tool being taken by stops in the planer bed. For the finishing cut on cast iron a broad nose tool is used; this should be ground with the proper clearance in all directions, and should be strong and stiff in order to eliminate all spring. In the final clamping particular care should be taken to see that the clamps do not bear on the casting at its weakest points.

Upon the completion of the finishing cut, the work is removed from the planer, and if the surface planed is for the sliding portion of a machine, the loose iron "dust" is removed with the scraper. This is carefully done so that the original tool marks are not obliterated. If on the other hand the planed surface is for a joint fit no scraping is performed on it at all. This development of the planing art has put the planer in the class with other highly accurate machine tools. D. T. H.

FOUR-SLIDE TOOLS FOR A WIRE-FORMING JOB*

AN EXAMPLE OF DIFFICULT WIRE BENDING REQUIRING INGENIOUS MACHINE DESIGN

BY CHESTER L. LUCAS†

In making the tools for forming the wire hook shown in Fig. 1, some interesting points in wire working were involved. The diameter of the steel wire is 0.150 inch and it will be seen in the illustration that there are bends in both horizontal and vertical planes, small bends *A* and *B* being in one plane while the large hook bend *D* is in the opposite

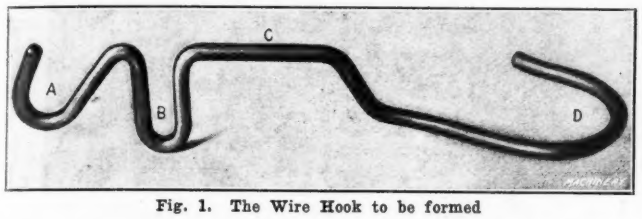

Fig. 1. The Wire Hook to be formed

plane. It was essential that the sides of bend *B* be parallel or at least that they should not diverge as they would naturally tend to if not restricted, even though bent around a parallel form. Along section *C* a patent date was to be stamped at the same time as the forming was done.

The illustration Fig. 2 shows the way this piece was bent, step by step; Fig. 3 illustrates the tools in place on the bed of the four-slide wire-forming machine in which they were used; of the machine. In Figs. 4 and 5, the vertical forming attachment was removed in order to give a clearer view of the rest of the mechanism. In general, the tools employed for this job are similar to any set of four-slide wire-forming tools, except for the vertical attachment, the forming being done around a central form by tools entering successively from the front, back, left and right.

In Fig. 3, referring to the plan view, the wire line is shown at *I*. The first operation consists in feeding the wire to the proper length just as it is shown in Fig. 4. After the wire has been fed to the proper length, passing just in front of the stationary former *J* and auxiliary former *K*, the front tools *L* and *M* come forward, pressing the wire against and around these two forms. This operation involves an interesting feature in that the front tools *L* and *M* are separately mounted, tool *L* being allowed a little play as it is pivoted about stud *N*, which is located near the center of the tool. Tool *M* is stationary, being tongued in position as may be clearly seen in Fig. 4. Another important feature is that auxiliary former *K* is set upon a ball and socket joint, hinged from a point lower down on the machine bed so that it is free to move a slight distance in any direction except to the rear. The object in having these tools flexible

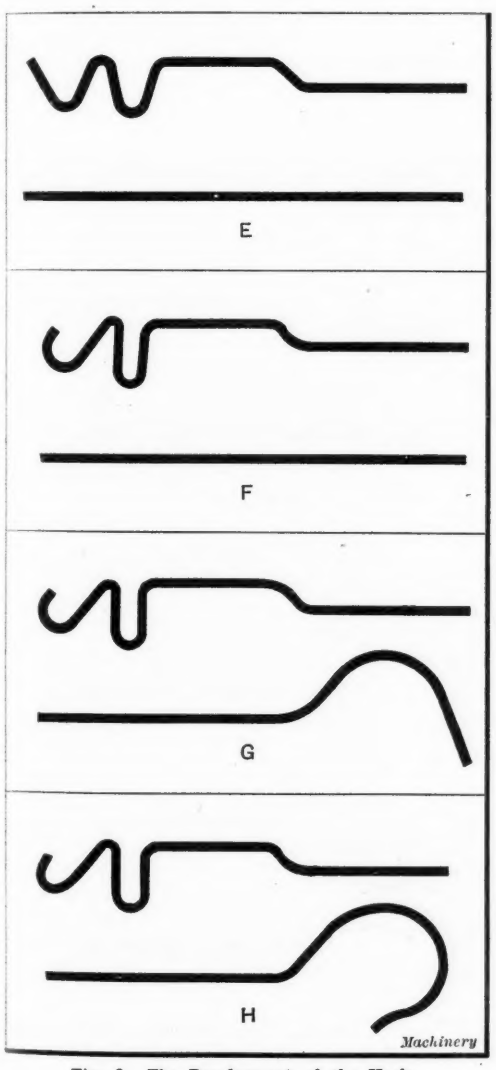

Fig. 2. The Development of the Hook

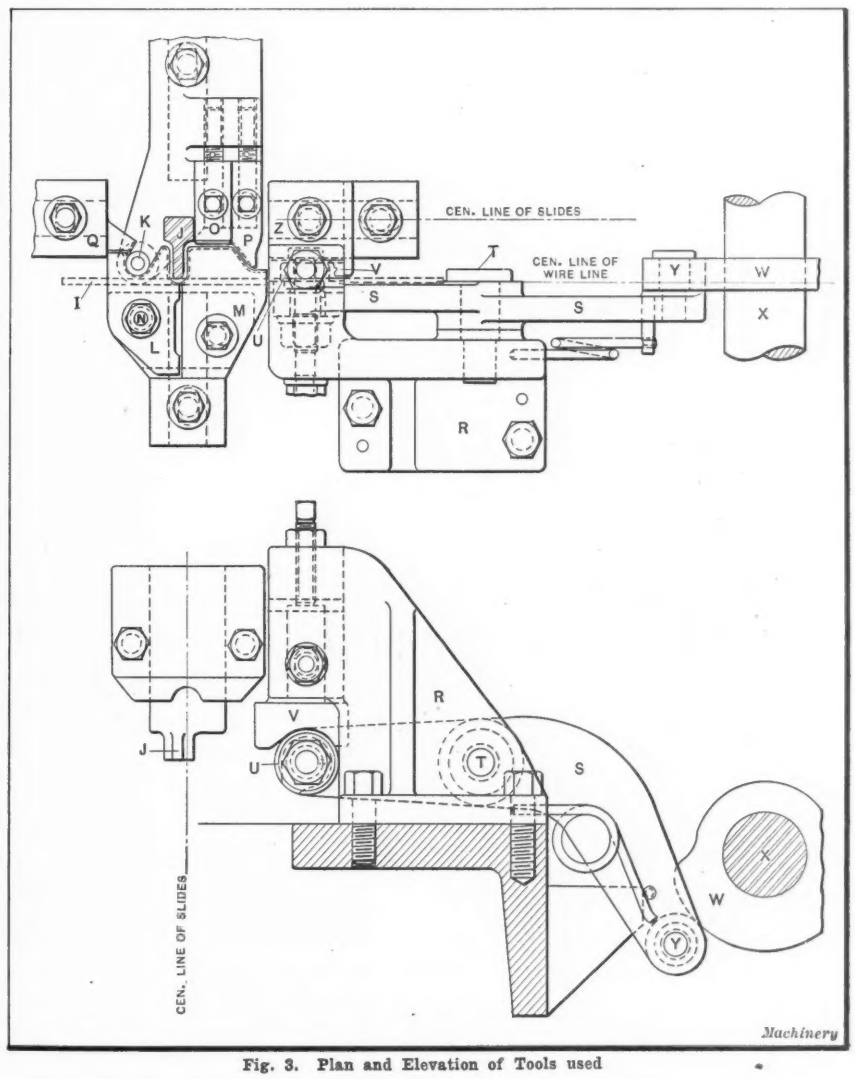

Fig. 3. Plan and Elevation of Tools used

Fig. 4 shows the tools as viewed from the front with the vertical forming attachment removed; Fig. 5 shows the front and back tools closed upon the wire; Fig. 6 is shown to make the action of the vertical forming attachment clear; and in Fig. 7 may be seen the tools as viewed from the rear is to fulfill the condition that the bend *B*, as indicated in Fig. 1, shall be made parallel. In order to do this a side movement of the tool is necessary to close the wire in against former *J*, carrying the bend slightly beyond the point of parallelism, so that when the initial tension in the wire has opened the bend the sides will be just parallel. The forward movement of the front tools does not complete the two small bends *A* and *B*, but leaves the wire in the partly formed

* For information on tools for the four-slide wire-forming machine, see MACHINERY, February, 1912, engineering edition; "Tools for Four-slide Automatic Wire Forming Machine."

† Associate Editor of MACHINERY.

condition shown at *E* in Fig. 2. The back tools *O* and *P* next come in, and these are also mounted separately because tool *O* comprises a stamp containing the patent date which is imprinted on the wire. The function of tool *P* is merely to make the angular bend shown at the right of section *C*, Fig. 1.

Just after the back tools come in, the left-hand side tool *Q* comes forward and its tip catches the outstanding end of the wire, wrapping it around auxiliary former *K*, and as

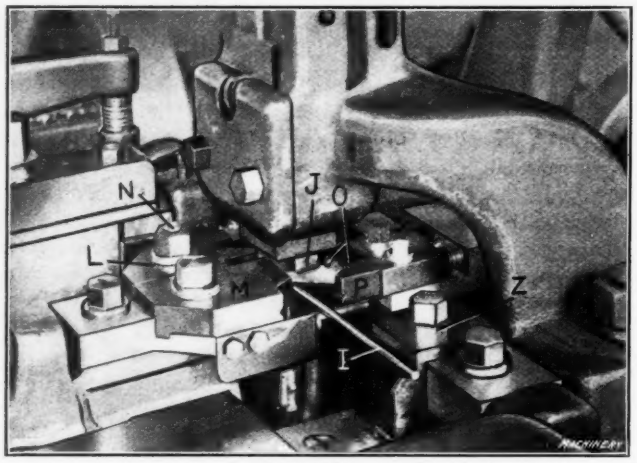

Fig. 4. Front View of Tools in Place on Wire-forming Machine

former *K* and front tool *L* are free to move sideways a limited amount, when the shoulder of left-hand side tool *Q* strikes the right-hand side of the front tool *L*, the auxiliary former and wire are forced in against the thinner shoulder section of former *J*. This completes the work on this end of the wire, leaving bend *B* in a parallel condition just as is

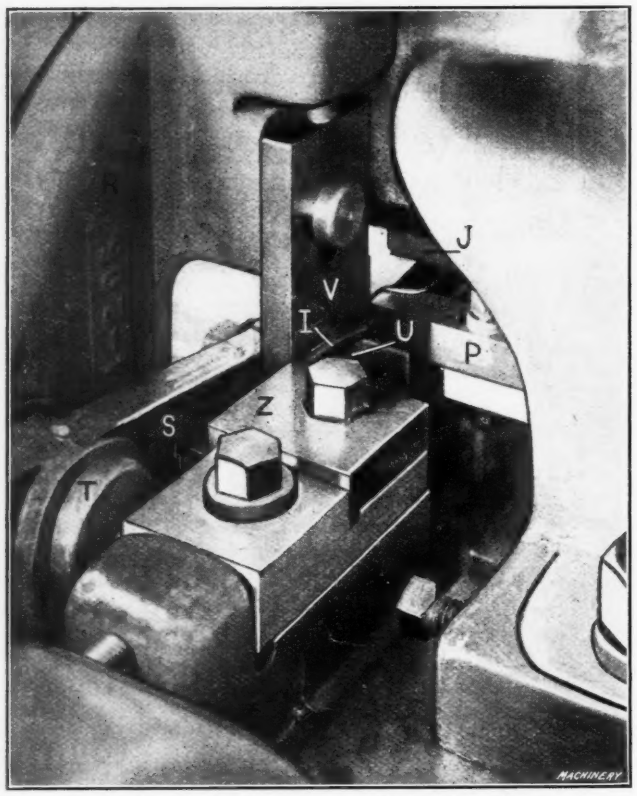

Fig. 6. The Vertical Forming Attachment in Place

required. At *F*, in Fig. 2, may be seen the result of the action of front, back and left side tools.

At this point the wire and tools are in the relation shown in Fig. 5 and it is upon the end of the wire which projects that the vertical hook bend *D* must be made. In this illustration, Fig. 5, the vertical forming attachment has been removed, but it is adequately shown in Fig. 6 and also in the line illustration Fig. 3. By referring to this part of the mechanism it will be seen that the fixture consists of a bracket casting *R* which is bolted to the bed of the machine. This fixture supports the stationary forming tool *V*, most clearly shown in Fig. 6, into which the wire must be pressed. The position of this tool is adjustable vertically upon the bracket. For forcing the wire into the cavity of the tool, lever *S*, which is pivoted upon the body of the fixture on stud *T*, is employed. At the forming end of this lever, which is normally below the wire line, is the former-roll *U*. Thus, it will be seen that it is only necessary to depress the outer end of this lever so as to force roll *U* up, pressing the wire into the cavity in tool *V*. This is accomplished by means of cam *W* on the right-hand camshaft of the machine, indicated

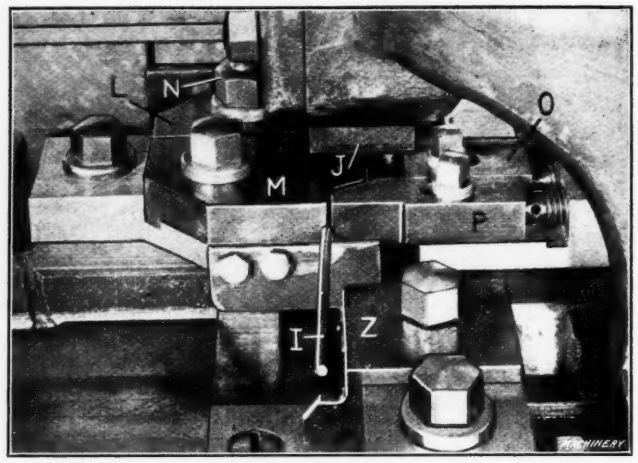

Fig. 5. Showing the Front and Back Tools closed on the Wire

at *X* in Fig. 3. The cam bears against cam-roll *Y* and being timed properly, forces the wire up into tool *V*, which gives the hook the appearance indicated at *G* in Fig. 2, with the end of the hook unfinished. A dwell on the cam keeps roll *U* against the wire in tool *V*, while right-hand forming tool *Z* comes forward and curls the end of the hook around the roll, leaving it

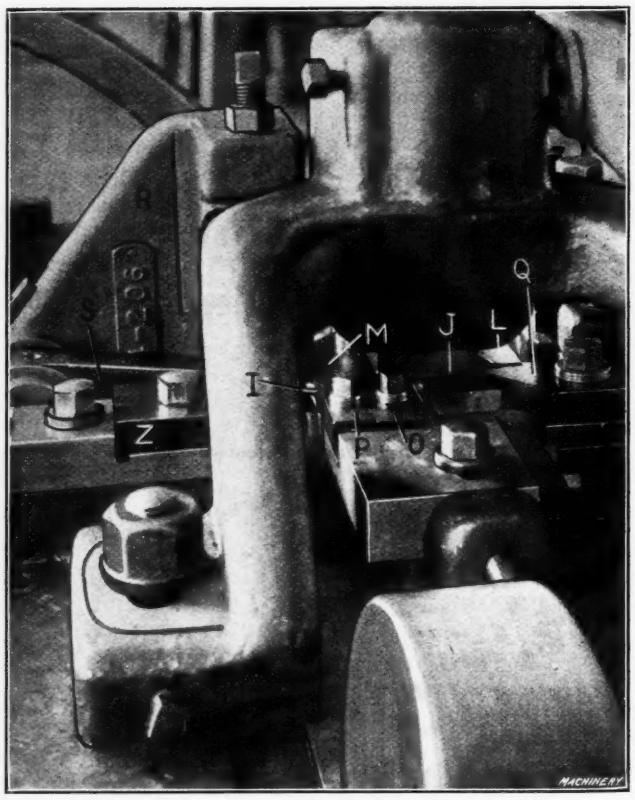

Fig. 7. View of Tools and Attachment from the Rear

in the finished condition indicated at *H* in Fig. 2. The hook is ejected from the machine by an ejector plate on former *J*, as soon as the tools withdraw.

After explaining the operation of the different tools, a better general idea may be obtained from the illustration Fig. 7, which shows all of the tools in place including the vertical forming fixture. The operation of the tools is very satisfactory and the wire pieces are cut off, formed and stamped, being turned out at the rate of eighty per minute. These tools were made by the Baird Machine Co., Bridgeport, Conn., for use in a Baird standard four-slide wire-former.

DUPLICATION OF GEARS HAVING LONG AND SHORT ADDENDA

COMPILED WITH SPECIAL REFERENCE TO THE CONDITIONS MET WITH IN AUTOMOBILE REPAIR SHOPS

BY E. WINSLOW BAXTER*

In designing bevel-gear drives for automobiles, a number of manufacturers have adopted the long and short addendum style of tooth, which is especially desirable where the pinion has a small number of teeth in proportion to the gear. This form of tooth avoids undercut in the pinion teeth, and makes it possible to obtain teeth of equal strength in both the gear and pinion. The larger or ring bevel gear is made with a short addendum and the pinion with a long addendum. The manner in which the pinion teeth are strengthened by increasing the addendum is shown by Figs. 1, 2 and 3. Fig. 1 shows the tooth outline of a thirteen-tooth pinion having standard teeth; and Fig. 2 shows the tooth outline of a pinion of the same number of teeth, but with the addendum increased about 50 per cent over the standard dimension, the dedendum being decreased by the same amount, thus keeping the depth standard. Both pinions have a 14½-degree pressure angle; if a 20-degree pressure angle had been selected, the undercut would have been less noticeable in the case of the standard tooth.

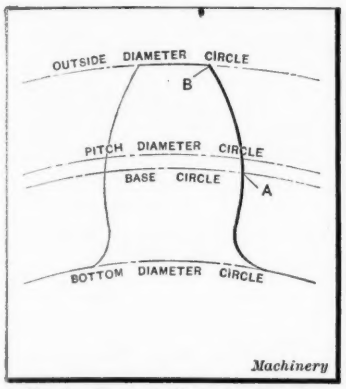

Fig. 1. Tooth Outline of a Thirteen-tooth Pinion with Standard Teeth

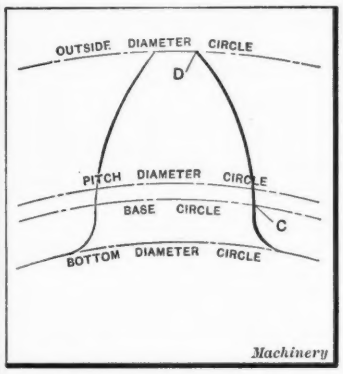

Fig. 2. Tooth Outline with Addendum increased Fifty Per Cent

We know that the involute curve is drawn by unwinding a cord from the base circle of a gear, as shown in Fig. 3. Therefore, we see that the outline of the tooth shown in Fig. 1 is taken from the involute curve between points *A* and *B*, while that of the gear shown in Fig. 2 is taken from the involute between points *C* and *D*. Thus, in order to prevent undercutting, and to strengthen the teeth of a pinion having a small number of teeth in relation to the gear, it is only necessary to have the tooth outline follow the involute curve to a point as close to the base circle as is necessary to accomplish the desired results. As the pitch diameter and the diameter of the base circle are not increased or decreased by this procedure, it necessarily follows that the addendum is increased and the dedendum decreased. The large gear has to be treated in the reverse manner in order to have the teeth mesh properly. Making the pressure angle 20 degrees instead of 14½ degrees lessens the undercut, as it reduces the base circle and produces the same results but in a lesser degree. In this connection, it may be mentioned that the base circle diameter is found by multiplying the pitch diameter by the cosine of the pressure angle, which is 0.96815 for 14½ degrees and 0.93969 for 20 degrees.

Theoretically, it is possible to figure the proper relation of gear and pinion addenda to each other for all ratios, in order to produce gear teeth of equal strength, and Mr. Hugo Bilgram has prepared charts for the purpose of selecting such addenda. The Gleason Works have adopted the following approximation for all high ratios:

Gear addendum = 3/10 of the working depth.
Pinion addendum = 7/10 of the working depth.

The working depth is equal to twice the standard addendum. In the examination of foreign made bevel gear drives using this style of tooth, the writer has found that the ratio of the gear addendum to the pinion addendum varies with each set of gears examined, and in order to render the duplication of such gears easier, the following formulas and tables were evolved. In order to explain the method, we will assume that a set of bevel gears has been ordered to duplicate samples which are measured as carefully as possible and the dimensions tabulated as follows:

	Gear	Pinion
Number of teeth	48	13
Measured outside diameter	9.66 inches	3.14 inches
Measured face angle	76¼ degrees	18⅓ degrees
Measured cutting angle	71¼ degrees	13½ degrees
Measured depth of tooth	0.43 inch	0.43 inch

The number of teeth on the pinion being odd, the outside diameter is found by adding to the diameter of the bore, twice the distance from the edge of the bore to the tip of a tooth.

If we figure the outside diameters according to the method used for standard gears and find that the outside diameter of the pinion is larger and that of the gear smaller than the dimensions of the gears to be duplicated, we will know that this pair of gears has been designed with long and short addendum teeth. After a little experience it will not be necessary to figure the standard dimensions, as ordinarily an inspection of the pinion tooth is all that is necessary. By referring to the table, we find that the nearest standard pitches having whole depths around 0.43 inch are ⅝ inch circular pitch (whole depth 0.429 inch) and 5 diametral pitch (whole depth 0.431 inch). We will therefore assume that the gears are 5 diametral pitch, as this will be the easiest dimension to use in the calculations. The standard outside diameters for 48 and 13 tooth, 5 pitch gears are 9.704 inches and 2.986 inches, while the measured diameters are 9.66 inches and 3.14 inches. As the measured diameter for the gear is smaller and that for the pinion is larger than the standard dimensions, we may safely assume that the gears are cut with long and short addenda. As the center angles remain the same as in the standard gears

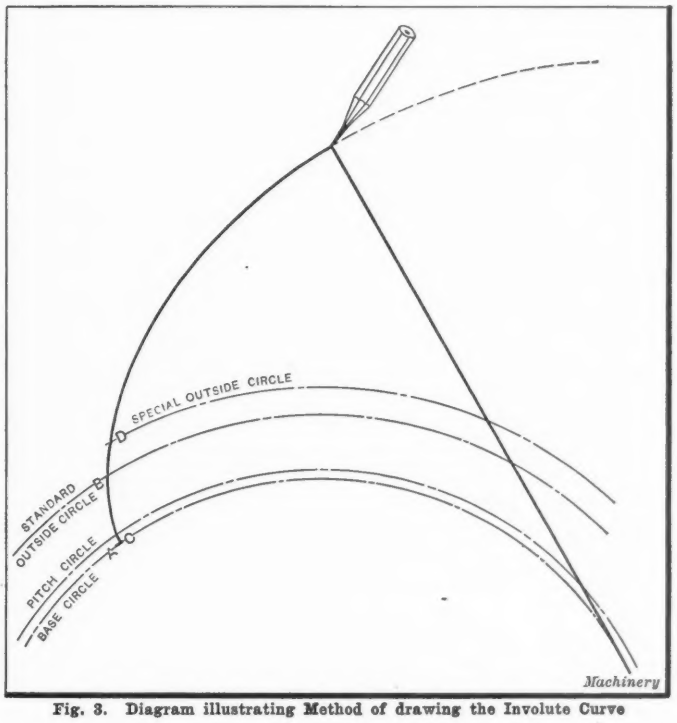

Fig. 3. Diagram illustrating Method of drawing the Involute Curve

(on account of the pitch diameters not changing) we have only to look them up in a handbook on gearing or calculate them from the following formula. Calling a the center angle of the gear:

$$\text{Tangent } a = \frac{\text{Number of teeth in gear}}{\text{Number of teeth in pinion}}$$

Center angle pinion = 90 degrees − a

Calculating for 48 and 13 teeth, we have:

$$\text{Tangent } a = \frac{48}{13} = 3.69230$$

Center angle gear = 74 degrees 51 minutes = a

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Center angle pinion = 90 degrees — a = 90 degrees — 74 degrees 51 minutes = 15 degrees 9 minutes.

Tabulating the known quantities and representing those that are unknown by suitable letters, we have the following:

Number of teeth on gear	48
Number of teeth on pinion	13
Center angle of gear	74 deg. 51 min.
Cosine of center angle of gear	0.26135
Center angle pinion	15 deg. 9 min.
Standard addendum of gear and pinion or half the working depth	Z

Z also equals the pitch diameter of either gear divided by the number of teeth.

Pressure angle 14½ degrees.

The pressure angle may be found by taking an impression of the backs of the large gear teeth on paper and measuring with a protractor the angle which the side of the tooth makes with a line drawn through the center of the tooth in the direction of its length.

The formula for finding the outside diameters of a pair of bevel gears when the addenda are unequal in gear and pinion is as follows: Pitch diameter + 2 (special addendum × cosine of center angle) = outside diameter.

Substituting the known and unknown quantities, we get:

TABLE OF ADDENDA FOR DIAMETRAL AND CIRCULAR PITCHES

(Whole depth = 2.157 × addendum)

Addendum in Inches	Whole Depth in Inches	Diametral Pitch	Circular Pitch: Fraction, Inches	Circular Pitch: Decimal, Inches	Metric Pitch Module in Millimeters
0.125	0.270	8	...	.....	....
0.126	0.272	...	...	.....	3.2
0.127	0.274	...	...	0.4000	....
0.128	0.276	...	...	.....	....
0.129	0.278	7¾	...	.....	....
0.130	0.280	...	...	.....	3.3
0.131	0.282	...	...	.....	....
0.132	0.285	...	...	.....	....
0.133	0.287	7½	5/12	.....	....
0.134	0.289	...	...	.....	3.4
0.135	0.291	...	...	.....	....
0.136	0.293	...	3/7	.....	....
0.137	0.295	...	...	.....	....
0.138	0.298	7¼	...	.....	3.5
0.139	0.300	...	7/16	0.4375	....
0.140	0.302	...	...	.....	....
0.141	0.304	...	4/9	.....	....
0.142	0.306	...	...	.....	3.6
0.143	0.308	7	...	.....	....
0.144	0.311	...	...	.....	....
0.145	0.313	...	5/11	.....	....
0.146	0.315	...	...	.....	3.7
0.147	0.317	...	...	.....	....
0.148	0.319	6¾	...	.....	....
0.149	0.321	...	7/15	.....	....
0.150	0.324	...	...	.....	3.8
0.151	0.326	...	...	.....	....
0.152	0.328	...	...	.....	....
0.153	0.330	...	...	.....	3.9
0.154	0.332	6½	...	.....	....
0.155	0.334	...	...	.....	....
0.156	0.337	...	...	.....	....
0.157	0.339	...	...	.....	4.0
0.158	0.341	...	...	.....	....
0.159	0.343	...	½	0.5000	....
0.160	0.345	6¼	...	.....	....
0.161	0.347	...	...	.....	4.1
0.162	0.349	...	...	.....	....
0.163	0.352	...	...	.....	....
0.164	0.354	...	...	.....	....
0.165	0.356	...	...	.....	4.2
0.166	0.358	...	...	.....	....
0.167	0.360	6	...	.....	....
0.168	0.362	...	...	.....	....
0.169	0.365	...	11/32	.....	4.3
0.170	0.367	...	...	.....	....
0.171	0.369	...	...	.....	....
0.172	0.371	...	...	.....	....
0.173	0.373	...	...	.....	4.4
0.174	0.375	5¾	6/11	.....	....
0.175	0.378	...	...	.....	....
0.176	0.380	...	...	.....	....
0.177	0.382	...	5/9	.....	4.5
0.178	0.384	...	...	.....	....
0.179	0.386	...	9/16	0.5625	....
0.180	0.388	...	...	.....	....
0.181	0.390	...	...	.....	4.6
0.182	0.393	5½	4/7	.....	....
0.183	0.395	...	...	.....	....
0.184	0.397	...	...	.....	....
0.185	0.399	...	...	.....	4.7
0.186	0.401	...	7/12	.....	....
0.187	0.403	...	...	.....	....
0.188	0.406	...	...	.....	....
0.189	0.408	...	13/23	.....	4.8
0.190	0.410	5¼	...	.....	....
0.191	0.412	...	5/8	0.6000	....
0.192	0.414	...	...	.....	....
0.193	0.416	...	...	.....	4.9
0.194	0.419	...	...	.....	....
0.195	0.421	...	...	.....	....
0.196	0.423	...	...	.....	....
0.197	0.425	...	...	.....	5.0
0.198	0.427	...	...	.....	....
0.199	0.429	...	9/14	0.6250	....
0.200	0.431	5	...	.....	....
0.201	0.434	...	...	.....	5.1
0.202	0.436	...	7/11	.....	....
0.203	0.438	...	...	.....	....
0.204	0.440	...	...	.....	....
0.205	0.442	4⅞	...	.....	5.2
0.206	0.444	...	...	.....	....
0.207	0.447	...	...	.....	....
0.208	0.449	...	...	.....	....
0.209	0.451	...	29/32	.....	5.3
0.210	0.453	4¾	...	.....	....
0.211	0.455	...	...	.....	....
0.212	0.457	...	3/8	0.6666	5.4
0.213	0.459	...	...	.....	....
0.214	0.462	...	...	.....	....
0.215	0.464	...	...	.....	....
0.216	0.466	4⅝	...	.....	5.5
0.217	0.468	...	...	.....	....
0.218	0.470	...	...	.....	....
0.219	0.472	...	11/16	0.6875	....
0.220	0.475	...	...	.....	5.6
0.221	0.477	...	...	.....	....
0.222	0.479	4½	...	.....	....
0.223	0.481	...	7/10	0.7000	....
0.224	0.483	...	...	.....	5.7
0.225	0.485	...	...	.....	....
0.226	0.488	...	...	.....	....
0.227	0.490	...	5/7	.....	....
0.228	0.492	4⅜	...	.....	5.8
0.229	0.494	...	23/32	.....	....
0.230	0.496	...	...	.....	....
0.231	0.498	...	8/11	.....	....
0.232	0.500	...	...	.....	5.9
0.233	0.503	...	...	.....	....
0.234	0.505	...	...	.....	....
0.235	0.507	4¼	...	.....	....
0.236	0.509	...	...	.....	6.0
0.237	0.511	...	...	.....	....
0.238	0.513	...	...	.....	....
0.239	0.516	...	4/9	0.7500	....
0.240	0.518	...	...	.....	6.1
0.241	0.520	...	...	.....	....
0.242	0.522	4⅛	...	.....	....
0.243	0.524	...	...	.....	....
0.244	0.526	...	...	.....	6.2
0.245	0.529	...	...	.....	....
0.246	0.531	...	...	.....	....
0.247	0.533	...	...	.....	....
0.248	0.535	...	7/19	.....	6.3
0.249	0.537	...	25/32	.....	....
0.250	0.539	4	...	.....	....
0.251	0.541	...	...	.....	....
0.252	0.544	...	...	.....	6.4
0.253	0.546	...	...	.....	....
0.254	0.548	...	...	.....	....
0.255	0.550	...	4/5	0.8000	....
0.256	0.552	...	...	.....	6.5
0.257	0.554	...	...	.....	....
0.258	0.557	3⅞	...	.....	....
0.259	0.559	...	13/16	0.8125	....
0.260	0.561	...	9/11	.....	6.6
0.261	0.563	...	...	.....	....
0.262	0.565	...	...	.....	....
0.263	0.567	...	...	.....	....
0.264	0.569	...	...	.....	6.7
0.265	0.572	...	5/6	0.8333	....
0.266	0.574	...	...	.....	....
0.267	0.576	3¾	...	.....	....
0.268	0.578	...	...	.....	6.8
0.269	0.580	...	27/32	.....	....
0.270	0.582	...	...	.....	....
0.271	0.585	...	...	.....	....
0.272	0.587	...	...	.....	6.9
0.273	0.589	...	7/9	.....	....
0.274	0.591	...	...	.....	....
0.275	0.593	...	...	.....	7.0
0.276	0.595	3⅝	13/15	.....	....
0.277	0.598	...	...	.....	....
0.278	0.600	...	7/8	0.8750	....
0.279	0.602	...	...	.....	7.1
0.280	0.604	...	...	.....	....
0.281	0.606	...	...	.....	....
0.282	0.608	...	...	.....	....
0.283	0.611	...	8/9	.....	7.2
0.284	0.613	...	...	.....	....
0.285	0.615	...	...	.....	....
0.286	0.617	3½	9/10	0.9000	....
0.287	0.619	...	...	.....	7.3
0.288	0.621	...	29/32	.....	....
0.289	0.623	...	10/11	.....	....
0.290	0.626	...	...	.....	....
0.291	0.628	...	...	.....	7.4
0.292	0.630	...	11/12	.....	....
0.293	0.632	...	...	.....	....
0.294	0.634	...	...	.....	....
.....	.....	...	...	.....	....
0.295	0.636	...	...	.....	7.5
0.296	0.639	3⅝	...	.....	....
0.297	0.641	...	17/32	.....	....
0.298	0.643	...	17/32	0.9375	....
0.299	0.645	...	...	.....	7.6
0.300	0.647	...	...	.....	....
0.301	0.649	...	...	.....	....
0.302	0.651	...	...	.....	....
0.303	0.654	...	...	.....	7.7
0.304	0.656	...	...	.....	....
0.305	0.658	...	...	.....	....
0.306	0.660	...	...	.....	....
0.307	0.662	...	...	.....	7.8
0.308	0.664	3¼	31/32	.....	....
0.309	0.667	...	...	.....	....
0.310	0.669	...	...	.....	....
0.311	0.671	...	...	.....	7.9
0.312	0.673	...	...	.....	....
0.313	0.675	...	...	.....	....
0.314	0.677	...	...	.....	....
0.315	0.680	...	...	.....	8.0
0.316	0.682	...	...	.....	....
0.317	0.684	...	...	.....	....
0.318	0.686	...	1	1.0000	....
0.319	0.688	...	...	.....	8.1
0.320	0.690	3⅛	...	.....	....
0.321	0.692	...	...	.....	....
0.322	0.695	...	...	.....	....
0.323	0.697	...	...	.....	8.2
0.324	0.699	...	...	.....	....
0.325	0.701	...	...	.....	....
0.326	0.703	...	...	.....	....
0.327	0.705	...	...	.....	8.3
0.328	0.708	...	1 1/32	.....	....
0.329	0.710	...	...	.....	....
0.330	0.712	...	...	.....	....
0.331	0.714	...	...	.....	8.4
0.332	0.716	...	...	.....	....
0.333	0.718	3	...	.....	....
0.334	0.720	...	...	.....	....
0.335	0.723	...	...	.....	8.5
0.336	0.725	...	...	.....	....
0.337	0.727	...	...	.....	....
0.338	0.729	...	1 1/16	1.0625	8.6
0.339	0.731	...	...	.....	....
0.340	0.733	...	...	.....	....
0.341	0.736	...	...	.....	....
0.342	0.738	...	...	.....	8.7
0.343	0.740	...	...	.....	....
0.344	0.742	...	...	.....	....
0.345	0.744	...	1 1/32	.....	....
0.346	0.746	...	...	.....	8.8
0.347	0.749	...	1 1/31	.....	....
0.348	0.751	2⅞	1 3/32	.....	....
0.349	0.753	...	...	.....	....
0.350	0.755	...	1 1/10	1.1000	8.9

Cosine of center angle pinion	0.96524
Measured outside diameter of gear	9.66 inches
Measured outside diameter of pinion	3.14 inches
Pitch diameter of gear	D
Pitch diameter of pinion	d
Addendum of gear (short)	X
Addendum of pinion (long)	Y

For the gear, $D + 0.5227\ X = 9.66$ inches = outside diameter (1)

For the pinion, $d + 1.93048\ Y = 3.14$ inches = outside diameter (2)

As the clearance and whole depths are the same for both gear and pinion in this style of gearing, the long addendum and the short addendum added together equal the working depth and also equal twice the "diameter addendum" $2Z$.

This gives us a third equation.

$$X + Y = 2\ Z \quad \text{or} \quad Z = \frac{X + Y}{2} \tag{3}$$

As previously stated, Z is the standard addendum for the depth, and Z multiplied by the number of teeth in each gear gives the pitch diameters of the gears. Therefore we derive the following:

$$48\ Z = D \tag{4}$$

$$13\ Z = d \tag{5}$$

Substituting these values of D and d in Equations (1) and (2) we get:

$$48\ Z + 0.5227\ X = 9.66$$

Simplifying $Z + 0.01089\ X = 0.20125$ (6)

$$13\ Z + 1.93048\ Y = 3.14$$

Simplifying $Z + 0.1485\ Y = 0.24154$ (7)

Substituting the value of Z from Equation (3) in Equations (6) and (7) and simplifying, we get:

$$\frac{X + Y}{2} + 0.01089\ X = 0.20125$$

$$X + Y + 0.02178\ X = 0.4025$$

$$1.02178\ X + Y = 0.4025 \tag{8}$$

$$\frac{X + Y}{2} + 0.1485\ Y = 0.24154$$

$$X + Y + 0.297\ Y = 0.48308$$

$$X + 1.297\ Y = 0.48308 \tag{9}$$

Multiplying Equation (8) by 1.297 and subtracting Equation (9) we get:

$$1.32525\ X + 1.297\ Y = 0.52204$$

$$X + 1.297\ Y = 0.48308$$

$$0.32525\ X = 0.03896$$

$$X = 0.11978 \text{ inch} = \text{addendum for gear (short).}$$

Substituting this value for X in Equation (9) we have:

$$0.11978 + 1.297\ Y = 0.48308$$

$$1.297\ Y = 0.3633$$

$$Y = 0.28010 \text{ inch} = \text{addendum of pinion (long).}$$

We can now get the value of Z by substituting both X and Y in Equation (3).

$$0.11978 + 0.28010 = 2\ Z$$

$$0.39988 = 2\ Z$$

$$Z = 0.19994 \text{ inch} = \text{standard addendum.}$$

Z is probably 0.200 inch and the pitch for this depth is 5 diametral pitch.

$X = 0.120$ inch which is 3/10 of 0.400 inch (whole depth)

$Y = 0.280$ inch which is 7/10 of 0.400 inch

as per the Gleason formula.

The large or ring gear is apt to shrink in hardening, the amount of this shrinkage depending upon the size of the gear, the kind of steel and the heat-treatment used. The shrinkage is not often more than 0.02 inch, but even this amount will affect the teeth of the gear by reducing the circular pitch, and if this shrinkage is not compensated for when turning and cutting the gear, the pinion will not mesh with the finished ring gear at the same place that it did before the ring gear was hardened. If we suppose that this shrinkage was not taken into account and amounted to 0.02 inch, the measured outside diameter of the large gear would be 9.64 inches and that of the small gear 3.14 inches, no appreciable shrinkage being evident in the pinion on account of its small size. By substituting these values in the preceding formulas, we can find whether or not the correct dimensions can be found under these conditions. If this calculation is made, it will be found that the small amount that the ring gear will shrink will not alter the results enough to cause any serious error.

From the above data, we can figure the correct face and cutting angles and outside diameters, using the measured values to check the calculations. The full data is tabulated below:

Long and Short Addendum Gears with 14 1-2 Degrees Pressure Angle

Ratio, 3 9/13 to 1
Diametral pitch, 5
Working depth 0.4000 inch
Whole depth, 0.4314 inch

	Gear	Pinion
Addendum	0.1200 inch	0.2800 inch
Dedendum	0.3114 inch	0.1514 inch
Face angle	76 deg. 14 min.	18 deg. 22 min.
Center angle	74 deg. 51 min.	15 deg. 9 min.
Cutting angle	71 deg. 16 min.	13 deg. 24 min.
Pitch diameter	9.600 inches	2.600 inches
Outside diameter	9.662 inches	3.140 inches
Difference between special and standard addendum angles	55 minutes	55 minutes
Difference between Bilgram system and standard addendum angles for the above ratio	59 minutes	59 minutes

* * *

Within the last ten years there has come about a tremendous change in the art of machine making, due largely to the advent of high-speed steel and possibly still more largely to the advent of the automobile. The tremendous orders for these machines have enlisted the brightest intellects and abilities of our best engineers, and while high-speed steel has taught many things to the machine manufacturer, the automobile manufacturers are teaching him many more; among the things that are taught, for example, is the rapidity with which machine operations can be performed in comparison to former practice. Let us consider for a moment, that, in the beginning of the making of automobiles, the four-throw crank would require, in many cases, ten hours' time to machine, and this same four-throw crank can be machined to-day, four each hour. Let any one who is familiar with cylinders, pistons, piston rings and other parts used in the manufacture of the automobile look upon their first experience and then look upon what is being done to-day and it is a revelation that, if it had been foretold ten or twelve years ago would be looked upon just as skeptically as we should have looked upon the statement that a machine would fly within a year had such a prediction been made a year before it happened.—*William Lodge in paper "Pension Plan for Employes," read before National Metal Trades Association Convention April* 10, 1913.

* * *

A properly made drawing, correctly dimensioned, will ordinarily give a machine builder all the information required to make the part of machine represented, and it will also afford him the data for estimating the cost of producing when limits, etc., are specified. But notwithstanding this well-known fact many men are likely to send samples instead of drawings. Samples are desirable sometimes when of complicated shapes difficult to show clearly on a drawing, but hardly otherwise. Certainly the example of an Austrian concern in the matter of sending a sample should be avoided. It wanted a quotation of price on a machine and a guarantee of production on a single forging. A sample of the forging weighing two hundred pounds was sent. The machine tool builder had to pay freight and duty and was thus put to considerable trouble to get the piece to his plant. A drawing which could have been sent by mail without delay or expense would have answered the requirements fully, except that of making an actual test on precisely that shaped piece which was hardly necessary.

* * *

Allgemeine Elektricitäts Gesellschaft, Berlin, has produced a series of moving picture films showing the process of manufacturing electric cables from start to finish. These films are lent for lectures to technical societies and institutions. Every stage of manufacture is shown, from the arrival of the copper ingots to the shipping of the completed cable.

COLORING IRON AND STEEL PRODUCTS*

PROCESSES OF METAL COLORING—PREPARING WORK—PICKLING—COLORING BY HEAT—BROWNING

BY E. F. LAKE†

How to give various iron and steel products a desired color in the easiest and cheapest manner, is often a problem with manufacturers. The art of coloring metal is very old. Some very good specimens have been found in the ruins left by the Aztecs and Incas. The Japanese and East Indians have done such work for several centuries. Probably the Japanese excel all others, it having become a real art with them. Americans and Europeans are so far ahead of Japan in chemistry that there is no comparison and yet we are not able to produce the bloom of fruit on metals, which they do almost to perfection.

Three General Processes of Metal Coloring

There are three ways in which to produce colors on metals, namely: First, by heat-treatment; second, by dipping in a bath; third, by electroplating. Often two of these methods are used in combination. A fourth might be added, that of brushing or rubbing a powder, or liquid, onto the piece to be colored. This is so similar to the dipping process, however, that it can be classed under that head. None of these metal coloring processes can be learned from a few receipts that may be printed. Metal coloring is in reality a trade in itself and must be learned.

Some of the solutions get weaker with use, and the last article treated will be of a different color from the first. Nearly all of the coloring materials have different effects on cast iron, wrought iron and malleable iron and will produce different shades, if not different colors. The chemical composition of the steels is so varied that no set of rules will apply to all steels. Likewise the preparation of the metal before coloring and the treatment given it after coloring must be changed to suit the kind of metal being colored. Hence it is necessary to know the metal that is being worked upon. It is always best to first experiment with a few pieces and see if uniform results are being obtained. It is a good rule not to treat miscellaneous steel pieces by the one coloring process, although some of the plating processes that deposit heavy coatings might be relied upon.

Preparing Work for Coloring

Preparing the work for the coloring operation is of the most vital importance. It is absolutely necessary to remove all grease, and the removal of all other foreign substances for the surfaces to be colored is of just as much importance. In fact, only the clean metal surface should present itself to the coloring materials, no matter what their nature may be. When all the layers of oxide, grease, dirt, etc., have been removed the entire exposed surface can be given a uniform color and a quantity of pieces will be the same shade if the other conditions are properly looked after.

Rust-proof Black Finish

When a rough surface, such as is presented by castings, forgings, etc., is to be given the rust-proof black finish, sand blasting is the quickest and cheapest method of cleaning the work. In this black finish the metal is oxidized and coated with black magnetic oxide of iron. One method of producing this is to heat the work to a red heat in a muffle furnace in the presence of steam and hydrogen gas. A small amount of gasoline, injected with the steam, improves the color. The work should be subjected to red heat in the muffle for about an hour. If the work is given a thin coating of linseed oil after it has cooled off the color will be deepened and present a smoother appearance.

This coating is quite hard and not easily worn away, and is a dead black. It is free from the red oxide that has spoiled so much work of this kind. The hydrogen gas is generated by passing steam over red hot iron chips or turnings. Cast iron, malleable iron and steel may all be given this black finish. The principle on which it is based is that of giving the surface all the oxide it will take up so the oxygen in the air cannot reach it and cause corrosion. Tests have shown it to resist this action for many years and the color to be preserved.

Black Oil Finish

Black oil finish is produced by heating the work to a bright red; then quenching it in lard oil, afterward putting it back in the furnace to burn the oil off, and then quenching it in water. The oil must be kept cool and the water clean. A thin coat of linseed oil applied to the black gives the same results as described above. This coating is not durable but it will prevent rusting until the goods are sold, and is useful for such tools as can be heat-treated in the same operation.

Gun-metal Finish

Gun-metal finish is based on the same fundamental principle as the black finishes described above but is a great improvement over them and applicable to a finer class of work. For this work, as well as for the browns, blues or other fine colors that are produced on polished surfaces, the pieces must be cleaned by methods that will not injure these surfaces, as does the sand blast.

Grease and dirt are readily removed by boiling the work in a solution of one pound of potash to one gallon of water. This turns the grease to soap, which is absorbed by the water, and the dirt falls off from the work. The potash will last a long time and the water can be replenished as it boils away. When exhausted, the bath can be renewed by adding fresh potash. On small work, or a few pieces, stirring about in benzine or paraffine will remove the grease and dirt. If used continuously three vessels should be provided. In the first the bulk of the grease would be cut from the work; in the second the balance of it would be cleaned off; and the third should be kept clean to remove any particles that might still remain. The first two could contain paraffine and the third benzine.

After this cleaning the pieces should be washed with clean water and thoroughly dried. If boiling water is used they will dry in the air; if cold water is used clean sawdust is effective for drying them. The work should never be touched with the bare hands as the fingers are likely to leave grease marks.

Pickling Preparatory to Coloring

Scale, oxide, etc., are not removed by the above washing methods and hence a pickling in acid solutions is required. One part of sulphuric acid to twenty parts of water is often used for iron. This mixture leaves the work dark colored and sometimes it has a different appearance at the edges. To make the work bright, the following pickling solution should be used: Dissolve two ounces of zinc in one pound of sulphuric acid and mix this with one gallon of water; then add one-half pound of nitric acid. The volume of the bath should be twenty times that of the work, to prevent it from becoming weakened too soon. The glassy patches on cast iron, which are usually iron silicate, can be removed by hydrofluoric acid.

After pickling, the solution should be thoroughly washed off and the work brushed with steel scratch brushes revolving at from 600 to 1000 R. P. M. Cleaned work can be protected from rusting by keeping it immersed in water containing some caustic alkali until it is needed. Caustic soda and sodium carbonate are both effective for this purpose.

Polished steel surfaces can be pickled by immersing them in contact with a piece of clean zinc, in a moderately strong solution of the acid potassium sulphate and water. Hydrogen gas is liberated when the zinc decomposes the solution and this removes the oxide of iron or rust from the steel. Another good pickling solution for steel is made of twenty parts hydrochloric acid and eighty parts water. Iron and steel can also be pickled white, in concentrated nitric acid to which has been added some lampblack. After pickling, the work should always be thoroughly washed and scratch brushed.

Other Gun-metal Receipts and Methods

Several different chemical solutions have been used successfully in giving steel the gun-metal finish or black color. Among these are the following: Bismuth chloride one part,

* For further information on coloring metals, see "Shop Receipts and Formulas," published in MACHINERY, 1905, to date; "The Niter Process for Bluing Iron and Steel," April, 1910; "Producing Black Nickel Coatings on Metal Surfaces," January, 1909; "Metal Coloring," December, 1903.

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copper chloride one part, mercury chloride two parts, hydrochloric acid six parts and water fifty parts. Ferric chloride one part, alcohol eight parts and water eight parts. Copper sulphate two parts, hydrochloric acid three parts, nitric acid seven parts and perchloride of iron eighty-eight parts. Other solutions have been prepared from nitric ether, nitric acid, copper sulphate, iron chloride, alcohol and water, and from nitric acid, copper sulphate, iron chloride and water.

Applying these and finishing the work is practically the same in all cases. The surface of the work is given a very thin coating with a soft brush or sponge that has been well squeezed, and is then allowed to dry. If put on too thick the surface will be unevenly corroded and white spots will appear. The work is then put into a closed retort to which steam is admitted and maintained at a temperature of about 100 degrees F. until covered with a slight rust. It is then boiled in clean water for about fifteen minutes and allowed to dry. A coating of black oxide will cover the surface, and this is scratch brushed. After brushing, the surface will show a grayish black. By repeating the sponging, steaming and brushing operation several times a shiny black surface will be obtained that is lasting. For the best finishes these operations are repeated as many as eight times.

Another process employs a solution of mercury chloride and ammonium chloride which is applied to the work three times and dried each time; a solution of copper sulphate, ferric chloride, nitric acid, alcohol and water is then applied three times and dried as before; a third solution of ferrous chloride, nitric acid and water, is applied three times and the work boiled in clean water and dried each time; the third and last solution of potassium chloride is then applied and the work boiled and dried three times. The work is then scratch brushed and given a thin coating of oil. Ordnance for the French Government was treated in this way.

The above methods are useful for hardened and tempered steels, as they are only heated to about 100 degrees F. and this temperature does not draw the hardness. For steels that will stand 600 degrees temperature without losing the desired hardness, better and much cheaper methods have been devised.

The color does not form a coating on the outside, as with the other processes, but a thin layer of the metal itself is turned to the proper color, which should make the color wear well. By varying the temperature of the furnace, the time the work is in it, and the chemical, different colors can be produced from the light straws to the browns, blues, purples and black, or gun-metal finish. Rough or sand-blasted surfaces will have a frosted appearance, while smooth, polished surfaces will have a shiny brilliant appearance.

A variety of colors can also be produced on iron and steel by immersing the pieces, for different lengths of time, in a boiling hot solution of the following composition: Lead acetate fifty grains, sodium thiosulphate fifty grains, water five fluid ounces. A half-hour immersion will make the work black and a shorter time will make it steel-gray, blue, mixed purple and blue, purple, dark brown and light brown. By controlling the time, the desired color can be obtained. These colors are very beautiful but fade quickly. A coat of lacquer on top of the color, however, will preserve them for years. On top of a nickel plating these colors are exceptionally brilliant.

Coloring Steel by Heat

Producing colors on steel by heat-treatment is almost too well known to comment on here. Suffice it to say that 430 degrees F. produces a faint yellow, 460 degrees dark yellow, 490 degrees light brown, 500 degrees dark brown, 520 degrees light purple, 540 degrees dark purple, 560 degrees light blue, 580 degrees dark blue, 600 degrees blue green and 620 degrees black. By mixing potassium nitrate and sodium nitrate in an iron pot and melting them, the bath can be maintained at any of these temperatures. By immersing the work in this bath until it absorbs its temperature and then cooling it, any of these colors can be obtained. The work can be cooled by plunging it into boiling water and the coating of salt removed at the same time. A thin coating of these salts sticks to the steel and prevents the oxygen in the air from attacking the metal and altering the color while it is being transferred from the nitrate bath to the boiling water. The contained heat will dry the work when removed from the water.

Browning Iron and Steel

A good brown color can be obtained as follows: Coat the steel with ammonia; dry in a warm place; then coat with muriatic or nitric acid; dry in a warm place; then place in a solution of tannin or gallic acid; and again dry. The color can be deepened by placing the work near the fire, but it should be withdrawn the minute the desired shade is reached or it will turn black.

The U. S. Government adopted the following formula for browning gun barrels: Alcohol three ounces, tincture of iron three ounces, corrosive sublimate three ounces, sweet spirits of niter three ounces, blue vitriol two ounces, nitric acid one and a half ounce and warm water two quarts. The solution is applied with a sponge, allowed to dry for twenty-four hours, and after this the loose rust is removed by scratch brushing. A second coat is given in the same manner. After that the piece is boiled in water and dried quickly. A thin coat of boiled linseed oil or lacquer is then put on to preserve the color.

Another process for browning iron and steel consists of dissolving four ounces of copper sulphate in two quarts of water and then adding one ounce of nitric acid, one ounce of spirits of niter, two ounces of alcohol and one ounce of ferric chloride. Scratch brushing and rubbing with a piece of smooth hard wood will polish and burnish the work and a coat of shellac or lacquer will preserve the color. Rubbing with the polishing wood will give the lacquer or shellac a polished surface.

A solution that may be used in place of the above is spirits of niter one ounce, copper sulphate one ounce and water twenty ounces. This must be allowed to remain on the work for twenty-four hours and then brushed off with a stiff brush. The operations can be repeated enough times to get the depth of color desired.

To Produce Bronze-like Color

A warm bronze-like color can be produced by exposing iron or steel to the vapors of heated aqua regia, dipping them in melted vaseline, then heating until the vaseline begins to decompose and wiping it off with a soft cloth.

Another method of producing this bronze-brown color is to slightly heat the work, cover the surfaces evenly with a paste of antimony chloride, known as "bronzing salt," and let it stand until the desired color is reached. It can be made more active by adding a little nitric acid.

Still another bronzing process consists of soaking the work for some time in an acid solution of ferric chloride, then vigorously moving it about in hot water and allowing it to dry, and finally brushing with a waxed brush. The oxygen, liberated by the decomposition of the water, combines with the iron and forms a dark layer of oxide.

To Produce Gray Color

A gray color can be obtained by immersing the work in a heated solution of ten grains of antimony chloride, ten grains of gallic acid, 400 grains of ferric chloride and five fluid ounces of water. This is doubtless due to the antimony. The first color to appear is pale blue and this passes through the darker blues to the purple and finally to the gray. Thus if immersed long enough the metal will assume the gray color, but if not any of the intermediate colors may be produced. Used cold it is also one of the bronzing solutions.

Mottling

The mottled colors can be produced by heating the steel pieces to a good cherry red for several minutes in cyanide of potassium, then pouring the cyanide off and placing the pot of work back in the fire for five minutes and then quickly dumping the contents into clean water. To heighten the colors the work should afterward be well boiled in water and oiled while hot. This also carbonizes the work and larger lots could be handled in the regular carbonizing furnaces.

With the various plating methods and processes nearly any kind of solid or mottled colors can be produced. They can also be laid in different combinations of stripes in various ways. This, however, is a trade or professional art that is distinctly different from the chemical coloring methods described above and hence it will not be described in this article. There are also ways of electrolytically coloring metals but as this is usually done with electroplater's apparatus it can be classed with the plater's art.

MAKING BALL PLAYERS' SHOE PLATES

TOOLS USED FOR BLANKING, SWAGING, PIERCING, FORMING AND GRINDING

BY A. F. HORTON*

The discussion which has been published in the papers during the past season in regard to a discontinuance of the use of plates on ball players' shoes to avoid accidents in sliding bases, has been read by a large number of people, but very

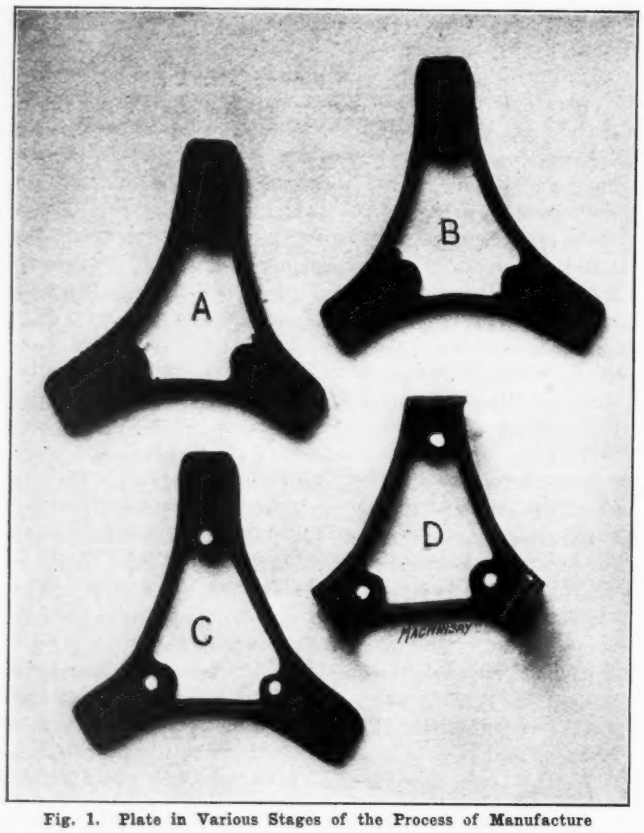

Fig. 1. Plate in Various Stages of the Process of Manufacture

few of this number know anything of the work involved in making these plates. An idea of the magnitude of this industry and the revenue derived from it will, however, be appreciated when it is known that a single firm manufactured nine thousand sets of plates during one season. Before entering into a discussion of the methods used in making plates of this kind, it may be mentioned that a set consists of one

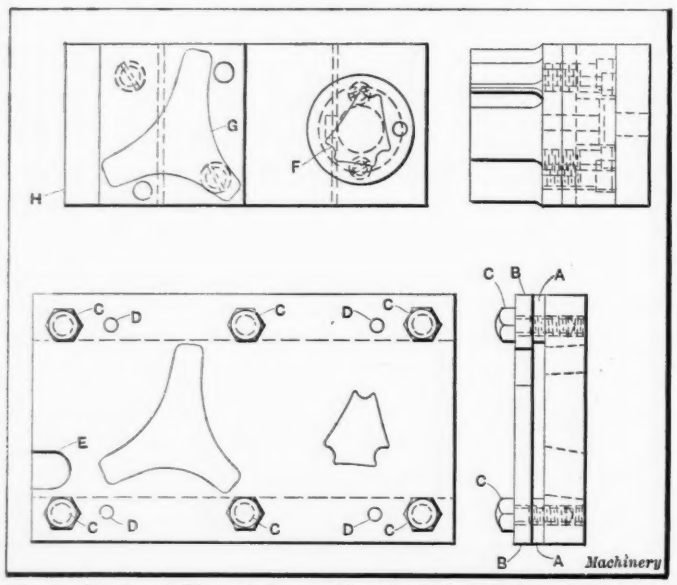

Fig. 2. Punch and Die used for punching the Hole in Middle of Plate and stamping the Blank from Ribbon Stock

right- and left-hand plate, to go under the ball of the foot, and a heel plate for both feet. These plates are made from a low grade of carbon steel and are tempered just enough to give them the required wearing quality, the temper used being approximately a "spring temper." It is necessary to make the plates as light as possible, and at the same time have them strong and hard enough to retain their edge when coming constantly into contact with all sorts of material on the ground. The manufacture of these plates involves twelve separate operations, which naturally means that a considerable amount of work is put on them, as each individual plate must be handled twelve times. Fig. 1 shows a plate at different stages in the process of manufacture. A blank is shown at *A*, as it comes from the blanking die; at *B* the blank has been swaged and trimmed on the inside and outside; at *C* the holes have been pierced for the rivets that secure the plate to the shoe; and at *D* the ends of the blank have been bent over and ground, thus completing the plate.

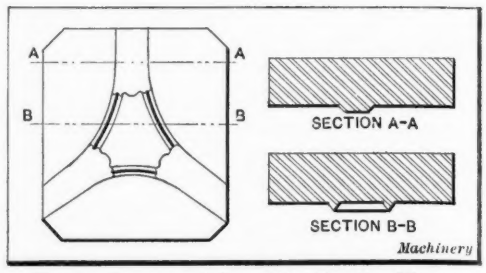

Fig. 3. Forces used in making Swaging Dies

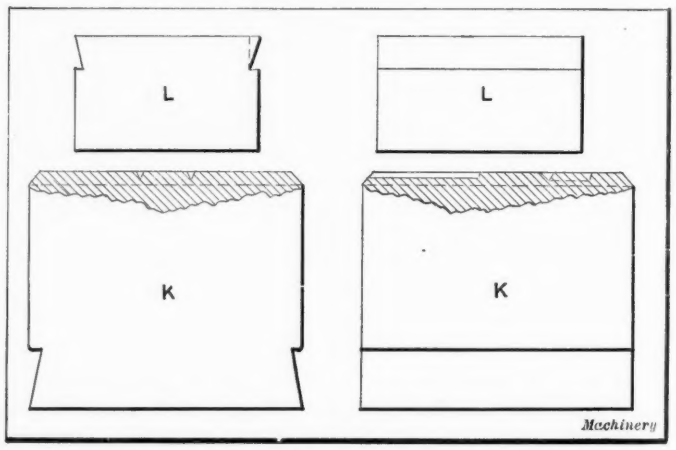

Fig. 4. Dies used for swaging Shoe Plates under a Drop Hammer

Fig. 2 illustrates the punch and die used for stamping the blanks from ribbon stock and punching out the metal that is to be removed from the center. The stock is fed over the face of the die between the gages *A* which are fastened to the die with screws *C* and dowel pins *D*. The slot *E* is cut in the end of the stripper plate to provide for the use of a finger gage which operates from the crankshaft of the press by means of a cam. The stock is fed over the die until it is stopped by the finger gage dropping into the hole in the stock from which the blank was stamped by the preceding stroke. When the stock has been located in this way, one stroke of the press blanks out the plate punched in the preceding operation and, at the same time, punches the hole in the next plate. This is continued until the strip is completely blanked. The stock is then reversed

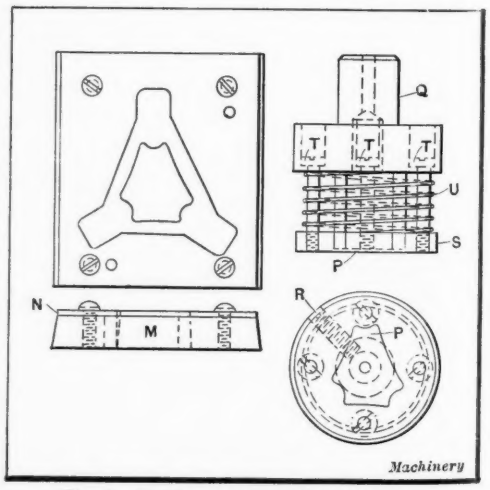

Fig. 5. Punch and Die used for trimming Inside of Plates

*Address: Swain Place, Wakefield, Mass.

and run through the die a second time, thus interlocking the blanks with those that were stamped out during the preceding passage of the stock over the die. The punches *F* and *G* are made of tool steel and are fastened to the punch pad *H* by means of screws and dowel pins to prevent them from turning. The top of the punch pad is machined to dovetail into the gate of the press.

The next operation consists of swaging the blanks, this work being done under a drop hammer with the metal hot. The same blanks can be used for both right- and left-hand toe plates, but the blanks are placed on one side to be swaged for right-hand plates and on the other side to be swaged for left-hand plates. Fig. 3 shows the forces used for making the

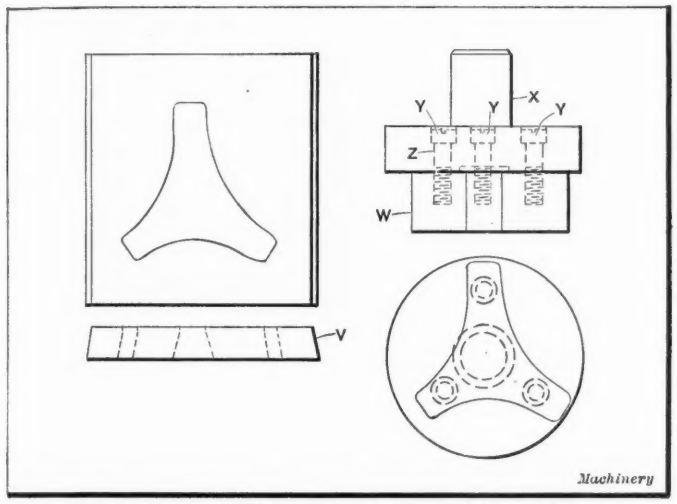

Fig. 6. Punch and Die used for trimming Outside of Plates

female swaging dies. Three different forces are required for the production of dies for right- and left-hand toe plates and heel plates respectively. The forces are made of tool steel and machined to the shape indicated in Fig. 3. The section *B-B* on a well made shoe plate must be formed to a sharp edge and be as light as possible in order to reduce weight and enable the soil to be shed from the plate. After these forces have been machined and finished, they are hardened and tempered ready to be used in the following manner: The lower swaging die, shown at *K* in Fig. 4, is made of composite steel, the lower part consisting of wrought iron while the upper part is made of tool steel to a depth of about one inch.

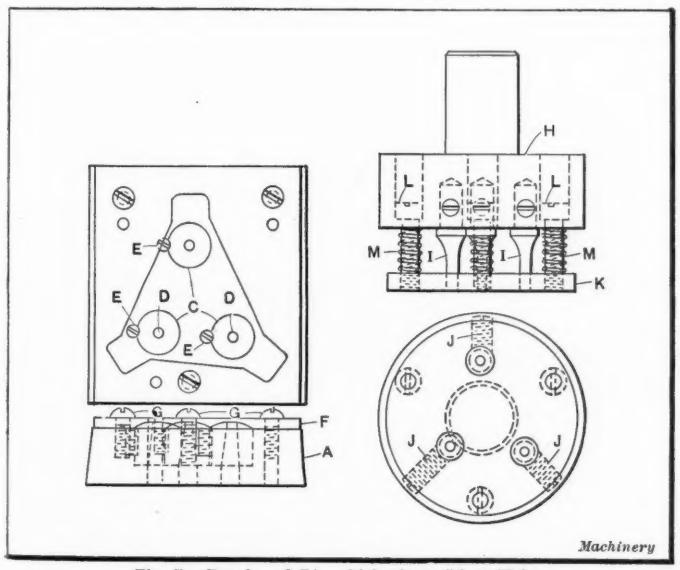

Fig. 7. Punch and Die which pierce Rivet Holes

The joint between these two parts is welded together. The bottom of the die is machined to fit the dovetail in the bed of the drop hammer and the top surface of the die is left flat. The die block is next placed in the furnace and heated to a red heat, and then placed in position under the drop hammer. The force illustrated in Fig. 3 is then placed in the desired position on the die and the hammer allowed to drop on it; this drives the force into the face of the die and the required number of blows of the hammer is applied to secure an impression of the desired depth. The die is then allowed to cool, and while it still retains a certain amount of heat muriatic acid is poured upon its face to remove the scale produced by the hot forging. After the die is cool it is returned to the drop hammer and again struck to remove all shrinkage; it is then polished, hardened and tempered. The upper die *L* in Fig. 4 is made of tool steel and machined to fit the dovetail in the hammer; it is hardened and tempered

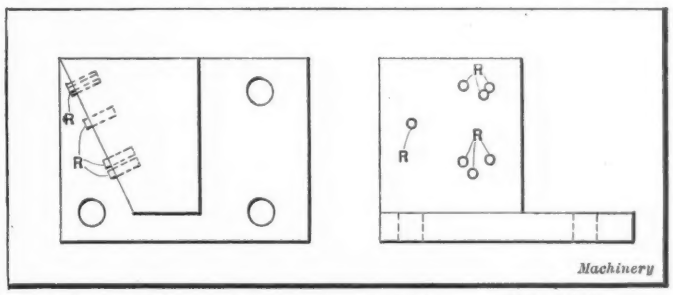

Fig. 8. Fixture used for grinding the Plates on a Disk Grinder

and the lower face is ground to an accurate flat surface. The dies are now ready to be mounted in the drop hammer for use. The blanks are heated in a large gas furnace built especially for this class of work. The hot blanks are then taken from the furnace one by one and placed in position on the die where one blow of a five-hundred pound hammer forces the metal down into the impression in the lower die.

The next operation consists of trimming the insides and outsides of the plate to remove the surplus stock which is left after the swaging operation has been completed. The trimming tools used for this purpose are illustrated in Figs. 5 and 6. In Fig. 5, the die *M* is made of tool steel with the sides machined to fit the dovetail in the die-holder. The hole in the die is machined to the required shape and the hole in the gage plate *N* locates the work in the required position. The lower end of the punch *P* trims the hole in the plate to the required shape and a shank is provided at its upper end to fit into the punch-holder *Q*. The screw *R* is used to hold the punch in position in the punch-holder. The round stripper *S* is made of machine steel and fastened to the punch-holder by screws *T* which pass through counterbored holes from the top. The spring *U* passes around the outside of these screws and operates the stripper. In using this punch and die, the work is placed in position in the gage and the press tripped; the punch then trims the fin from the inside of the plate, and as it rises the stripper forces the plate off the punch. Referring to the tools for trimming the outside of the plates shown in Fig. 6, the die *V* is of similar construction to the one just described, but no gage is required to locate the work, as the shoe plate is located in position to be trimmed when dropped into position in the die. The trimming punch *W* is made in two sections, the lower part of the punch being of tool steel and made to fit the punch-holder *X* which is made of machine steel. The punch is secured to the punch-holder by screws *Y* and is hardened and tempered; no stripper is required as the trimmings remain on the face of the die and the plate is forced down through the hole. The press used for this purpose is equipped with a compressed air attachment to blow the trimmings off the face of the die after each operation.

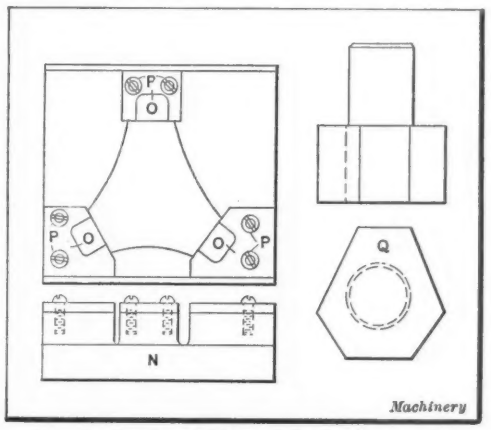

Fig. 9. Punch and Die used for bending up the Ends of the Spikes

The piercing punch and die shown in Fig. 7 are used for piercing the rivet holes in the plates. The die-block *A* is made of machine steel and has the dies *C* inserted in it and held

in position by screws *E*. The die-block *A* is machined on all sides and fitted in the dovetail of the die-holder. The holes are then laid out and bored and counterbored to receive the dies *C*. The center holes *D* in the dies are drilled to the size of the rivets which are to be used in securing the plates to the shoe. The dies are next placed in position in the holder and the holes for the screws *E* are drilled and tapped. The dies are then hardened and tempered ready for use. The gage plate *F* is fitted in the proper position and fastened to the die plate with screws and dowel pins. The piercing punch is made with a machine steel punch-holder *H* which has a shank to fit in the ram of the press. The holes for the piercing punches *I* are transferred through the corresponding holes in the die and these holes are then drilled to the required size. The punches are fitted to the punch-holder and held in position by the screws *J*. After completing these operations the punches are hardened and tempered. The round stripper *K* is made of machine steel and is fastened to the punch-holder by means of three screws *L*. The springs *M* surrounding these three screws actuate the stripper and force the plate from the punches after the piercing operation has been completed.

The fixture shown in Fig. 8 is used for grinding the spikes on the plates. This fixture is mounted on the table of a disk grinder and provides for bringing the spikes of the plates against the disk wheel at the right angle. Holes are drilled in the block of this fixture to receive the small pins *R*, which fit through the holes in the plates that were pierced in the preceding operation, and it will be seen that there are three combinations of holes in which the three pins can be placed in order to bring each of the spikes of the plate into the right position for grinding.

The punch and die shown in Fig. 9 are used for the final operation on the plate, which consists of bending the spikes over the required angle. The die *N* is made of tool steel. The bottom or face of the die is machined to the same contour as the sole of a shoe, and the gage plates *O* which locate the work in the die are held in position by means of screws *P*. The punch *Q* is made of tool steel with a shank to fit into the press. The sides of this punch are machined to the same angle as the die and provided with the necessary clearance to allow the spikes to be bent up between the sides of the punch and die. The punch is hardened but not tempered, as the plates are formed hot. The press used for this purpose is fitted with a compressed air attachment to remove the scale which is left in the die as the result of the hot forming.

The plates are now ready to be tempered and for this purpose they are placed in a continuous hardening furnace. After being hardened, they are passed through a lead bath which draws the temper to the required point, which, as previously mentioned, is in the nature of a "spring temper." Considerable care is required to get the temper exactly even, as it will be remembered that the heel plates are smaller than the toe plates. The importance of this precaution lies in the fact that it is desired to produce a product having a uniform temper color.

* * *

POWER TRANSMITTED BY HERRINGBONE GEARS*

BY J. E. HOLVECK†

The advantages claimed for herringbone gears are a smooth transmission due to continuity of engagement, adaptability to high pitch line velocities, quieter operation, higher efficiency and greater wearing qualities than are possessed by spur gearing. Since the teeth of herringbone gears are stronger than the teeth of spur gears, and as a wider face is possible for a given pitch, a further advantage is obtained through the more compact space which is occupied by a transmission system of this type. In designing drives of this kind, however, excessive pitch line velocities should be avoided, and for ordinary conditions, where the gears do not run in oil, 1500 feet per minute is a fair average velocity. Herringbone gears will operate satisfactorily at much higher speeds, but with correspondingly increased wear and noise.

TABLE I. POWER TRANSMITTED BY HERRINGBONE GEARS

Pitch	Teeth	Pitch Dia., Inches	Face, Inches										
				Velocity	400	600	800	1000	1200	1400	1500	1600	1800	2000
				R. P. M.	436	655	873	1090	1310	1525	1635	1745	1960	2180
			4	Cast iron	7	10	12	14	15	17	18	19	20	21
				Cast steel	13	18	23	27	31	35	36	37	40	42
6 D. P.	21	3½	5¼	Cast iron	9	13	16	18	20	22	24	25	26	28
0.5236″ C.P.				Cast steel	17	24	30	35	41	46	47	49	53	55
				R. P. M.	364	545	725	910	1090	1270	1360	1450	1630	1820
			5	Cast iron	10	14	17	20	23	25	26	27	29	31
				Cast steel	19	27	34	40	46	51	53	55	59	63
5 D. P.	21	4.2	6¼	Cast iron	13	18	21	25	29	31	32	34	36	39
0.6283″ C P.				Cast steel	24	34	43	50	58	64	66	69	74	79
				R. P. M.	292	437	584	730	875	1020	1090	1160	1310	1460
			6½	Cast iron	16	22	27	31	36	40	41	43	46	49
				Cast steel	29	41	53	62	71	80	83	86	93	99
4 D. P.	21	5¼	7¾	Cast iron	20	27	34	39	44	50	51	53	57	61
0.7854″ C.P.				Cast steel	36	51	66	77	88	99	103	107	116	122
				R. P. M.	255	382	510	637	765	892	955	1020	1150	1275
			7½	Cast iron	21	29	36	42	47	52	55	57	61	65
				Cast steel	39	55	70	83	95	105	110	114	123	131
3½ D. P.	21	6	9	Cast iron	26	36	45	52	58	65	68	71	76	81
0.8976″ C.P.				Cast steel	48	68	87	103	118	130	136	141	154	162

Machinery

TABLE II. POWER TRANSMITTED BY HERRINGBONE GEARS

Pitch	Teeth	Pitch Dia., Inches	Face, Inches										
				Velocity	400	600	800	1000	1200	1400	1500	1600	1800	2000
				R. P. M.	218	327	436	546	655	765	820	875	983	1090
			8¼	Cast iron	28	39	48	55	63	69	71	75	80	84
				Cast steel	51	72	92	110	126	139	146	151	165	173
3 D. P.	21	7	10½	Cast iron	36	50	61	70	80	89	90	96	102	107
1.0472″ C.P.				Cast steel	65	92	117	140	160	177	184	192	210	220
				R. P. M.	182	273	364	455	546	637	683	729	820	910
			10	Cast iron	41	57	70	80	91	101	106	109	116	122
				Cast steel	74	105	134	160	185	202	211	220	240	251
2½ D. P.	21	8.4	12½	Cast iron	51	71	87	100	114	126	132	137	145	152
1.256″ C.P.				Cast steel	93	130	167	200	228	253	264	274	300	314
				R. P. M.	145	218	291	364	437	510	546	580	655	730
			12½	Cast iron	64	89	109	125	143	158	166	171	182	195
				Cast steel	116	164	207	250	285	316	329	342	375	392
2 D. P.	21	10½	15½	Cast iron	79	111	136	154	178	196	206	213	226	242
1.5708″ C.P.				Cast steel	144	204	259	309	355	393	410	425	465	488
				R. P. M.	127	190	254	318	382	445	477	510	572	636
			14½	Cast iron	86	118	146	166	190	210	219	228	241	258
				Cast steel	155	218	279	331	378	420	438	455	496	522
1½ D. P.	21	12	18	Cast iron	106	146	180	206	234	261	272	282	300	320
1.7952″ C. P.				Cast steel	192	271	345	413	470	521	545	562	610	710

Machinery

* For further information on this subject see "Herringbone Gears," published in MACHINERY, January, 1912.

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The usual conditions met with in designing any form of gear drive are that power is to be transmitted from a motor spindle or other prime mover running at high speed to a machine which is required to operate at a considerably reduced speed. In selecting a pair of herringbone gears (as in the case of any other form of gearing) the designer naturally selects the smallest size of pinion which can be conveniently adapted to the service for which it is desired. By so doing, the size of the gear is reduced so that the least possible amount of space is required. Another reason for selecting a small pinion and corresponding gear to give the required speed reduction is to reduce the pitch line velocity to a minimum, as a higher velocity means increased wear and objectionable noise. Both the pinion and gear have the same pitch line velocity, and consequently, the same tooth strength. In the design of herringbone gears, a pinion with 21 teeth will be found satisfactory for average conditions, although it is possible to have a pinion with a smaller number of teeth, pinions with as few as 13 teeth having been used with satisfactory results. Where such small sized pinions are used, however, they are made solid on the shaft.

TABLE III. POWER TRANSMITTED BY HERRINGBONE GEARS

Pitch	Teeth	Pitch Dia., Inches	Face, Inches											
				Velocity	400	600	800	1000	1200	1400	1500	1600	1800	2000
				R. P. M.	110	160	220	270	330	380	410	435	490	540
			16	Cast iron	110	152	187	215	244	270	282	292	311	333
				Cast steel	199	280	358	426	488	540	564	585	640	671
1½ D. P.	21	14	20	Cast iron	137	190	234	269	305	338	343	366	388	406
2.0944″ C.P.				Cast steel	249	350	447	534	610	675	707	732	800	838

Machinery

FORMULAS

H. P. = horsepower.
N = revolutions per minute.
P = tooth pressure lbs.
K = admissible stress in lbs. per sq. in.
D = pitch circle dia. in inches
p = circular pitch in inches. For diametral pitch take nearest circular pitch.
W = total width of face in inches, including non-bearing width equal to 1 p.
V = velocity of pitch circle dia. ft. per min.

$$P = \frac{H.P.\ 33{,}000}{V}$$

$$P = \frac{p}{2.5} W K$$

The formulas and tables are based on a tooth angle of 23 degrees and the shearing stress of an imaginary straight tooth at pitch line thickness, assuming length of tooth contact equal to the total width of face. The values of the stress curves are entirely empirical, based on results of extended experience by the manufacturers, and lead to dimensions which are safe and reliable.

The above tables give H. P. transmitted by gears for various pitches and at pitch line velocities noted, also for two widths of faces corresponding to 8 and 10 p. H. P. given also for two materials, cast iron and cast steel.

As it is usual to first select the pinion and then determine the gear, a common size of pinion having 21 teeth is inserted for each pitch with the revolutions per minute corresponding to the velocities.

To find the H. P. of any other size pinion of a certain pitch, ascertain the velocity and under the nearest velocity in the table and opposite the pitch find the H. P.

Fig. 1 gives the value K by which the H. P. for pinions of other materials not given in the tables can be readily determined as follows: At 1500 feet per minute:

A brass gear will transmit	$\frac{375}{475}$	times that of	C. I.—multiplier	0.79
A gun metal gear will transmit	$\frac{600}{475}$	" " " " "	"	1.26
A phosphor bronze gear will transmit	$\frac{775}{475}$	" " " " "	"	1.63
A H. C. fgd. steel gear will transmit	$\frac{1350}{925}$	" " "	C. S. "	1.46

To compensate for wear the pinion should be of a tougher material than the gear. With cast-iron and cast-steel gears use forged steel pinions. Note.—Tables and formulas compiled from data by the Falk Co., Milwaukee, Wis., manufacturer of Wuest gears.

Tables I, II and III give the horsepower transmitted by this type of gearing for various pitches in cast iron and cast steel, with pitch line velocities ranging from 400 to 2000 feet per minute. The method by which these tables were calculated will be understood by referring to the formulas given in connection with Table III. These tables are used for determining the gear which is necessary for transmitting a given power at a specified speed. It is customary to use a pinion of tougher material than the gear, owing to the greater wear to which it is exposed, and the curves in Fig. 1 are used for obtaining the relative toughness of the different metals which are customarily used. These curves give the admissible stress in the gear teeth in pounds per square inch, and the values of *K* used in calculating the tables were taken from these curves. Figs. 2 and 3 show the relation between the revolutions per minute and pitch line speeds in feet per minute for pinions and gears of various pitch diameters.

To illustrate the method of using the tables, it is assumed that a herringbone gear drive is required to transmit 100 horsepower from a motor running at 650 revolutions per minute with a speed reduction of 12 to 1. In Table II, opposite 2½ pitch, 10-inch face and under 637 revolutions per minute, 101 horsepower is found to be the capacity of a cast-iron gear running at a pitch line velocity of 1400 feet per minute. This

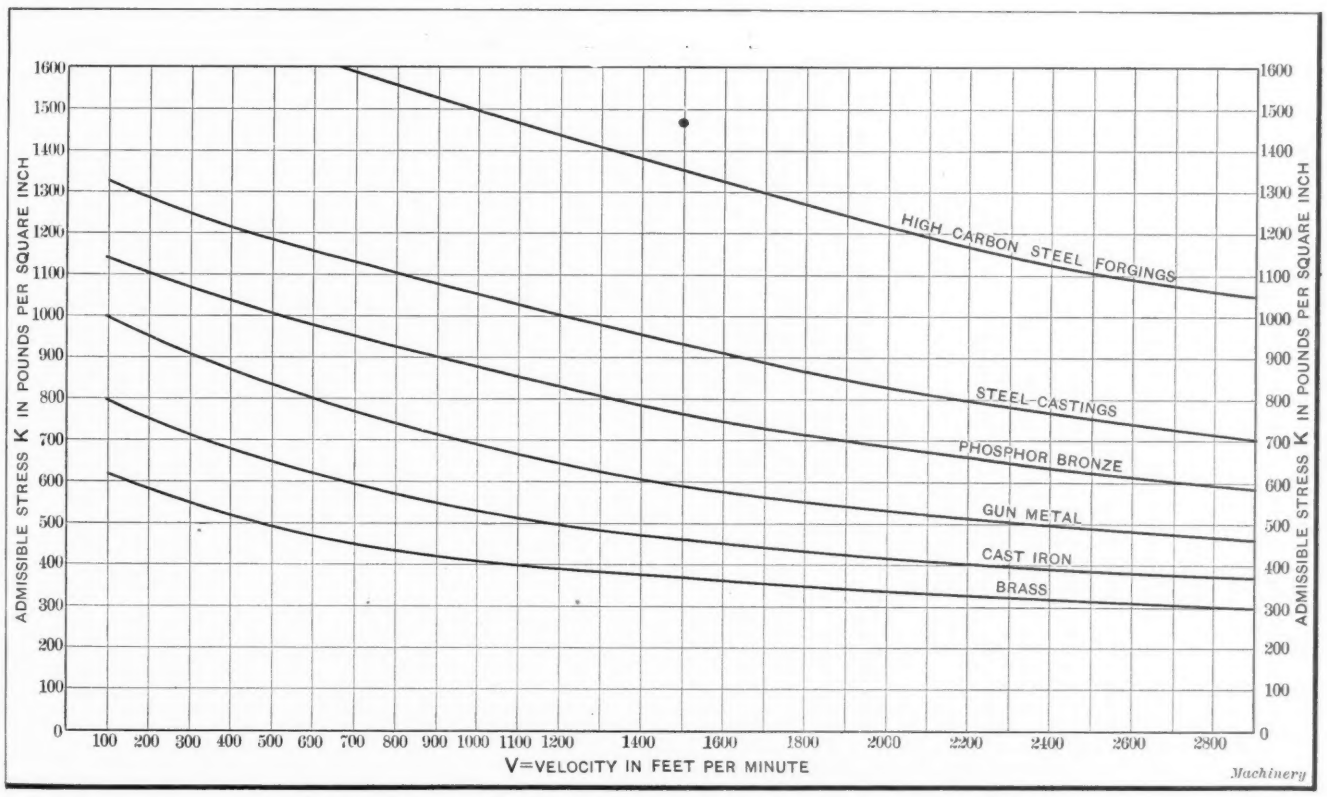

Fig. 1. Values of Admissible Stresses in Herringbone Gear Teeth of Various Metals

would necessitate $\frac{12 \times 21}{2.5} = 100.8$ inches pitch diameter for the gear. The pitch line velocity of a 17-tooth pinion would

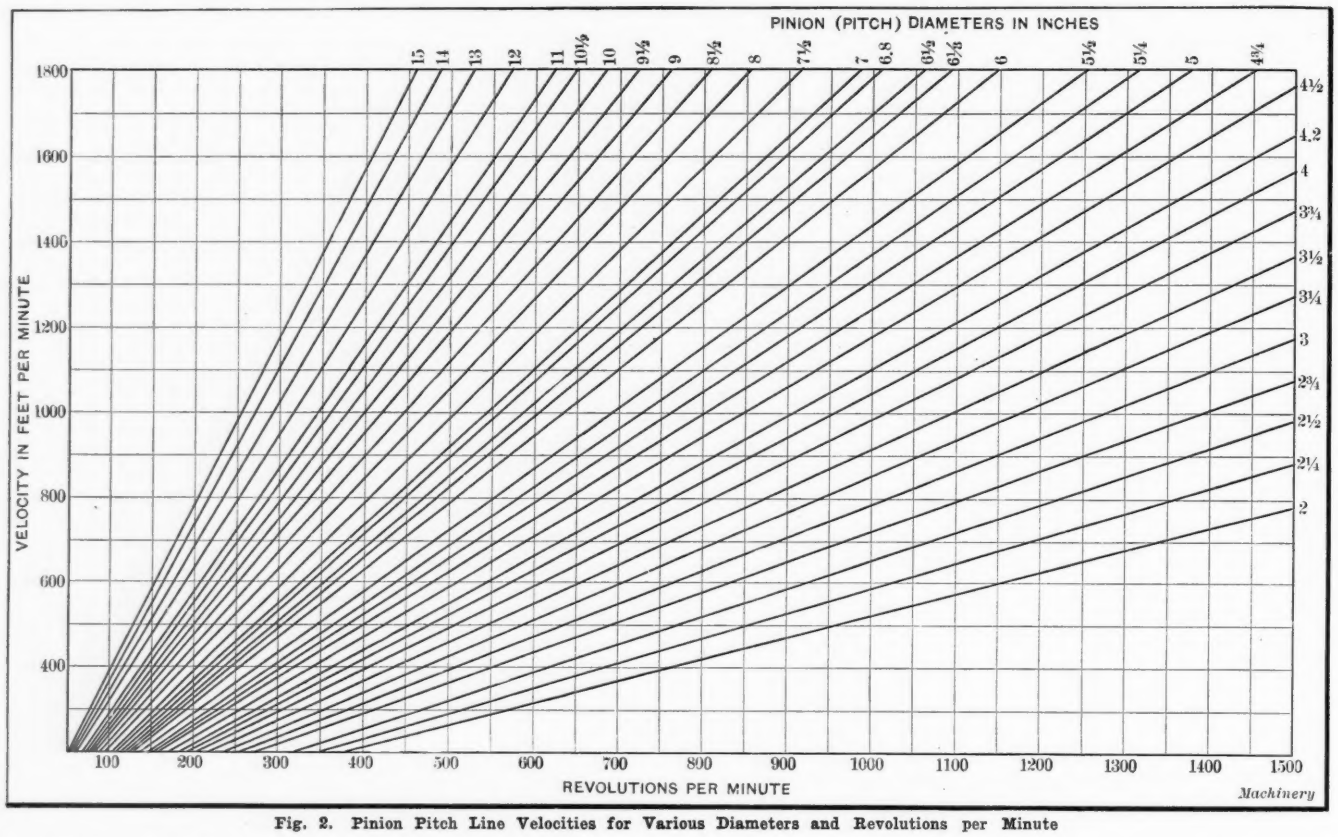

Fig. 2. Pinion Pitch Line Velocities for Various Diameters and Revolutions per Minute

be 1150 feet per minute, and in the 1200 foot column, it is seen that a gear running at this speed would transmit 91 horsepower. This means that a wider face gear must be used, if a 17-tooth pinion is to find successful application, the width of face required being $\frac{100 \times 10}{91} = 11$ inches. The pinion in either case should be made of cast steel or preferably of forged steel, to compensate for the greater wear to which it is exposed. If it is required to find the horsepower transmitted by a 2-pitch cast-steel gear having a pitch diameter of 90 inches by 10-inch face, running at 50 revolutions per minute, we find from Fig. 3 that the pitch line velocity is 1180 feet per minute. Under the 1200 column, in Table II, opposite 2 pitch and 12½-inch face, we find 285 horsepower, while the capacity of a gear of 10-inch face would be $\frac{10 \times 285}{12.5} = 228$ horsepower. Although the tables are calculated for 21-tooth pinions, they are universal in their application, it being merely necessary to find the corresponding pitch line velocity for any number of teeth.

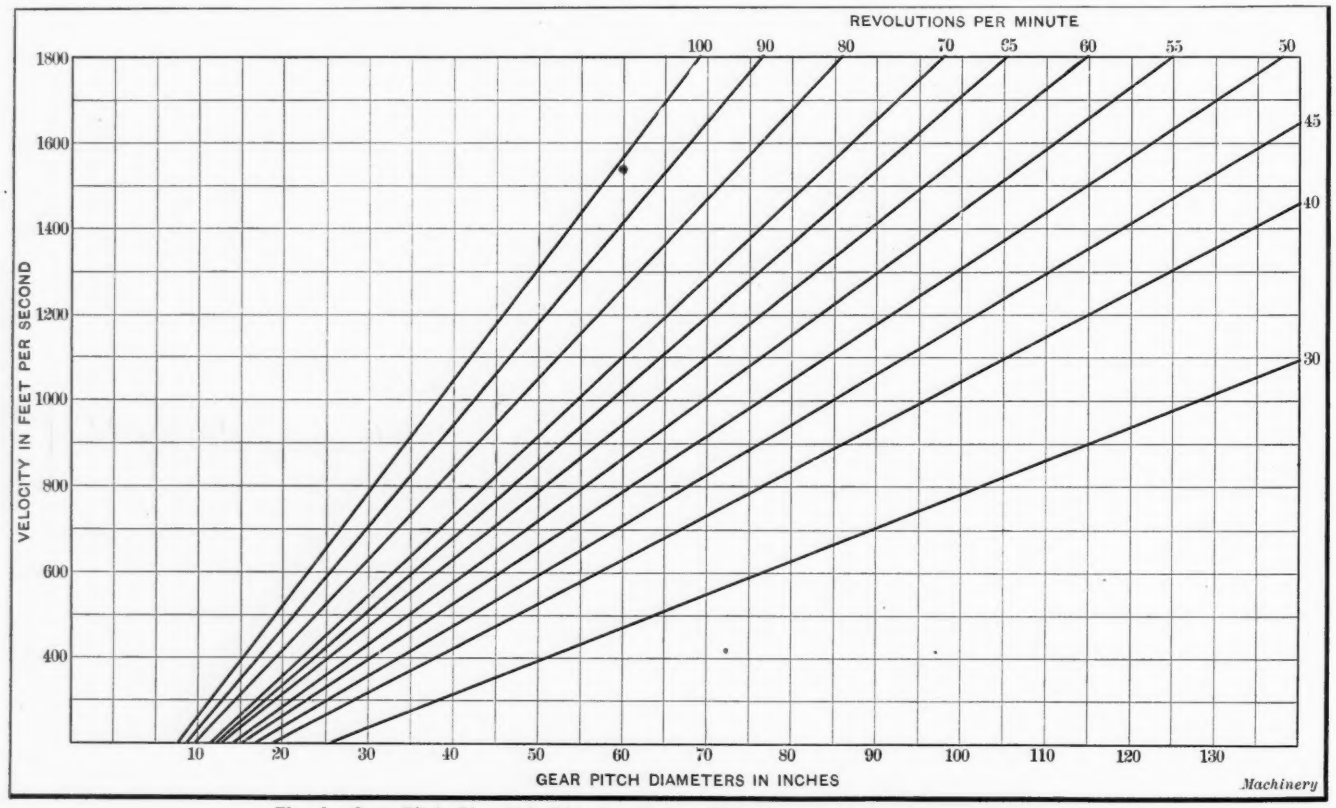

Fig. 3. Gear Pitch Line Velocities for Various Diameters and Revolutions per Minute

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Wireless messages were recently sent from the Sayville station, Long Island, N. Y., to the Nauen Tower near Berlin, Germany, a distance of about 3600 miles.

ECCENTRIC OR DIFFERENTIAL GEARS

AUTOMOBILE ENGINE REDUCTION MECHANISM—FORMULAS FOR VELOCITY RATIO

BY H. B. HEIGN*

No other field of mechanical design has brought about a more rapid development in gear mechanism than has that of the automobile. Not only have the different forms of gear teeth been perfected, but the combinations of gears used for velocity reduction have also been greatly improved. Almost all forms of gearing, as spur, helical, worm, annular and bevel, are represented in the modern automobile, and strength, quietness and efficiency are required from these combinations.

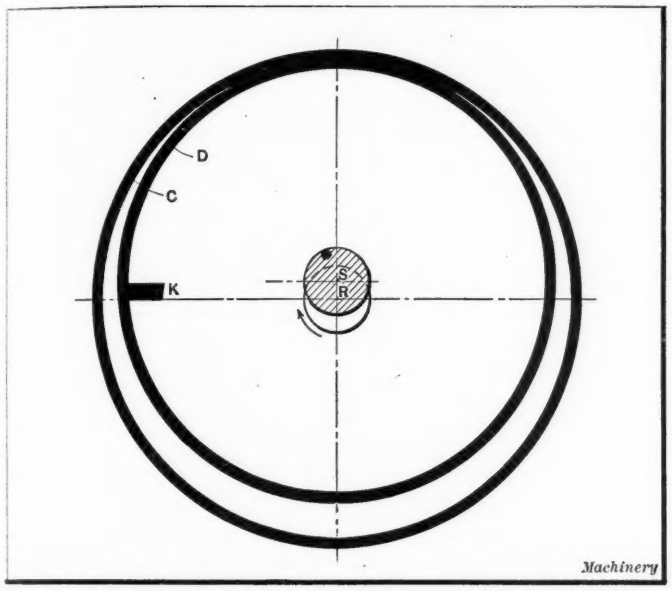

Fig. 1. Diagram illustrating Principle of Two-gear Eccentric Combination

It is the degree to which these requirements are attained which is largely responsible for the reputation of a car. In some of the recent developments in automobile accessories, such as self-starters and speedometers, conditions exist which require a high velocity ratio in a comparatively small space; this requirement has led to the development of what are commonly known as eccentric gear combinations. There are two general types of eccentric gears, *viz.*, those comprising two gears—a spur gear and an annular gear—and those consisting of four or more gears.

Principle of the Two-gear Type

The principle of the two-gear type of eccentric gear combination is illustrated in Fig. 1, where C and D represent an annular gear and a spur gear in mesh. The center of rotation of C is on the shaft R and the center of rotation of D on the crank S. We will assume that the shaft R is the driving shaft, and as it turns in the right-hand direction as indicated by the arrow, we shall be able to hold the gear D from absolute rotation on its own center by some external means K, thus limiting the movement of the gear D to the rotation of the crank S. As the shaft R rotates, the gear D measures off its circumference on the annular gear C, and as there is a difference in the circumferences of C and D, the point on the annular gear C that was in engagement with the spur gear D for the position shown in Fig. 1 will be moved ahead, as the result of the rotation, when the two gears reach this position again. The amount which this point is moved forward is equal to the difference in the circumference of the two gears, and it is this difference in circumference which determines the velocity ratio of the combination. Let

d = number of teeth in spur gear D

c = number of teeth in annular gear C

Then as the number of teeth in a gear is in direct proportion to the circumference, we have

$$\frac{\text{Circumference } C - \text{Circumference } D}{\text{Circumference } C} = \frac{c - d}{c}$$

That is, if R represents one revolution of the driving shaft and S the corresponding movement of the driven shaft, the equation for the velocity ratio is:

$$S = R\,\frac{c-d}{c} \qquad (1)$$

Principle of Four-gear Type

The principle of the four-gear type of eccentric combination is illustrated in Fig. 2, where R is the driving shaft which has annular gears A and C loosely mounted upon it. The crank or eccentric S has the gears B and D, which are integral with each other, loosely mounted upon it. The gear A in this combination is held and prevented from rotating by an external device K, and the reduced velocity is obtained from gear C. If we assume that these gears have numbers of teeth represented by a, b, c and d, respectively, and that rotation in the right-hand direction is positive and in the left-hand negative, the rotation of the shaft R in the right-hand direction, with the gear A stationary, will cause the gear B to rotate $\frac{b-a}{b}$ revolutions in the left-hand direction. As the gears B and D are integral with each other, the gear D will rotate $\frac{b-a}{b}\,d$ teeth in the left-hand or negative direction.

Gear D meshes with gear C, and gear C will move the same distance and in the same direction as previously determined for the rotation of the gear D. If we suppose that the gear D has no absolute rotation about its center S, then for each revolution of the shaft R, the gear D would move the gear C through $\frac{c-d}{c}$ revolutions in the right-hand direction or through $c-d$ teeth. To determine the absolute rotation Y of the gear

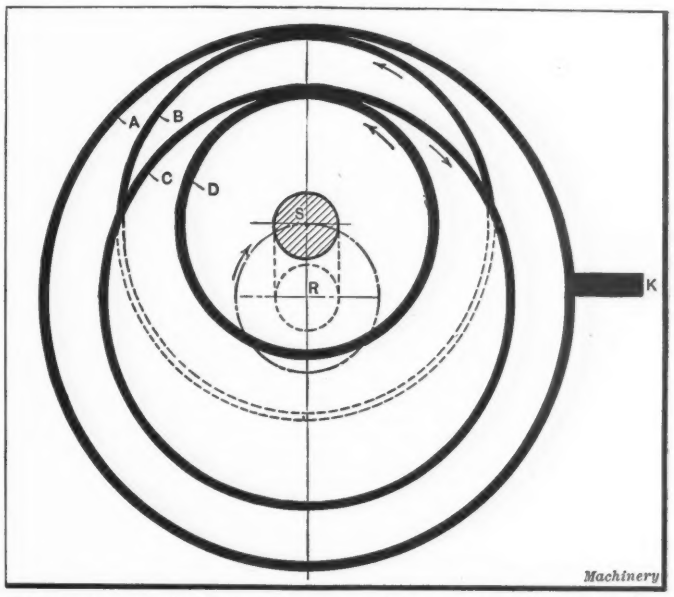

Fig. 2. Diagram illustrating Principle of Four-gear Eccentric Combination

C, we must add its rotations in either direction that correspond to one revolution X of the driving shaft R. This absolute rotation of the gear C is determined as follows:

$$Y = X\left(d\,\frac{(b-a)}{b} + (c-d)\right) \div c \qquad (2)$$

Simplifying (2) we have

$$Y = X\left[(b\,d \div b\,c) - (a\,d \div b\,c) + (c \div c) - (d \div c)\right]$$

$$Y = X\left(1 - \frac{a\,d}{b\,c}\right) \qquad (3)$$

By substituting in Equation (3), we are able to determine the required velocity ratio. Since we have considered rotation

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in the right-hand direction as positive and in the left-hand direction as negative, it is evident that if the fraction $\frac{a\,d}{b\,c}$ is greater than unity, the gear C will be rotated in the negative direction by the driving shaft R, which has positive rotation. From an analysis similar to the foregoing, it has been proved that if the gear B is fixed instead of the gear A, the velocity ratio between the shaft R and gear C will be

$$Y = X\left(1 - \frac{b\,c}{a\,d}\right) \qquad (4)$$

Assembly of the Two-gear Type

An assembly view of the two-gear type of eccentric gearing is shown in Fig. 3, which illustrates a typical reduction gear combination that changes automatically from the reduced velocity to direct drive. This combination is similar to those used by several manufacturers of electric automobile starters. The driving shaft A is connected to the electric starting motor and has the eccentric sleeve B secured to it. Sleeve B has four plungers C inserted in its flange; these plungers pick up the internal gear when the sleeve D becomes the driving shaft, due to the starting of the automobile engine and the conversion of the electric motor into an electric generator. Plungers C do not engage as long as shaft A is the driving shaft, on account of the difference in velocities of shaft A and internal gear E. In order to prevent the spur gear F from absolute rotation on its own axis, and to provide means for having it free on the roller bearings G, an oscillating plate H has been used which has four slots located at 90 degrees from one another that fit loosely over the rollers I and J. Rollers I are secured to gear F and rollers J to the gear-case; the oscillating plate H then has freedom of movement equal to the eccentricity of the crank, and still holds the gear F from turning. As the sleeve D is connected to the automobile engine, and the gear F is prevented from rotating, it is evident that if the engine should back-fire, the mechanism would be wrecked. This possibility has been guarded against in the following manner: The sleeve D has friction disks K bearing upon it, the pressure to produce the friction being obtained by springs L. When back-fire occurs, the clutch will slip if the back-fire torque is greater than the motor cranking torque. As an extra precaution, either friction roller clutches or electrically controlled pawls M also engage with the case if there is a tendency for the gear E to rotate in the reverse direction.

With this type of reducing mechanism, a reduction of from 23 to 1 to 26 to 1 is customarily used, and it is possible to obtain this reduction with gears having a difference of only two or three teeth. One electric starter company used 48 teeth on the spur gear and 50 teeth on the internal gear, which gives the following value of the velocity ratio $\frac{S}{R}$:

$$\frac{S}{R} = \frac{c - d}{c} = \frac{50 - 48}{50} = \frac{1}{25}$$

which is a reduction of 25 to 1; this appears to be about the proper reduction for the different sizes of commercial motors. It is evident that with internal gears meshing together and having a difference of only two teeth, a special tooth form must be used. It has been found by commercial tests that the ordinary form of bastard tooth gear has a very low efficiency, due to the oscillating contact of the teeth as the internal gear is moved forward. To partially overcome this low efficiency, a special form of tooth is used which has a total height of about 0.070 inch and a diametral pitch of 14; this gives the teeth the appearance of short rack teeth. The efficiency of this special gear tooth is about 80 per cent.

Assembly of the Four-gear Type

When the two-gear type of eccentric combination is used, it is evident that the reduction ratio is limited to about 50 to 1 unless very large gears are used. To avoid increasing the size of the units, the use of special gear teeth, and the oscillating contact of teeth, an eccentric combination of four gears may be adopted. As previously explained, two of the gears in such a combination are spur gears, which are made integral with each other, and two are independent annular gears. An assembly view of such a combination is shown in Fig. 4, which provides a reduction of 18 to 1 in starting the automobile engine, and then changes automatically to direct drive when the electric motor is converted into a generator. The high-speed shaft A is connected to the electric motor-generator, and the low-speed sleeve B is connected to the automobile engine. C_1 are roller clutches which engage with the gears D and E when the latter rotates in the right-hand direction. The roller clutches C_2 engage with the gear G when the latter rotates in the left-hand direction. As the shaft A drives in the left-hand direction, the resistance of the sleeve B against rotation causes the gear G to rotate in the left-hand direction, thus locking the clutches C_2. As soon as the gear G becomes stationary, the desired reduction of velocity is obtained by the rotation of the remaining gears. As soon as the automobile engine drives the gear combination, and the electric motor becomes an electric generator, the gears D, E and G tend to rotate in the right-hand or opposite direction, thus locking the clutches C_1 and releasing the clutches C_2; the gear combination then rotates as a flywheel. Solving Equation (3) for the reduction of the gear combination, we have

$$\frac{Y}{X} = 1 - \frac{a\,d}{b\,c} = 1 - \frac{17}{18} = +\frac{1}{18}$$

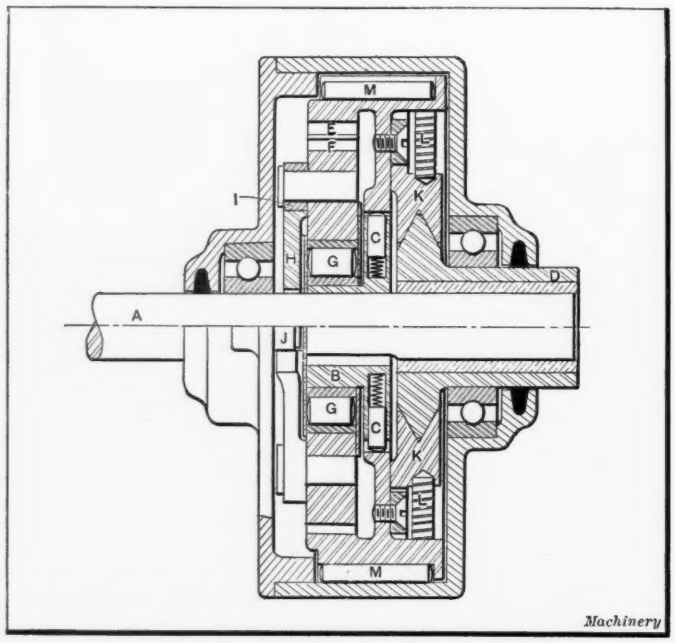

Fig. 3. Assembly of the Two-gear Eccentric Combination

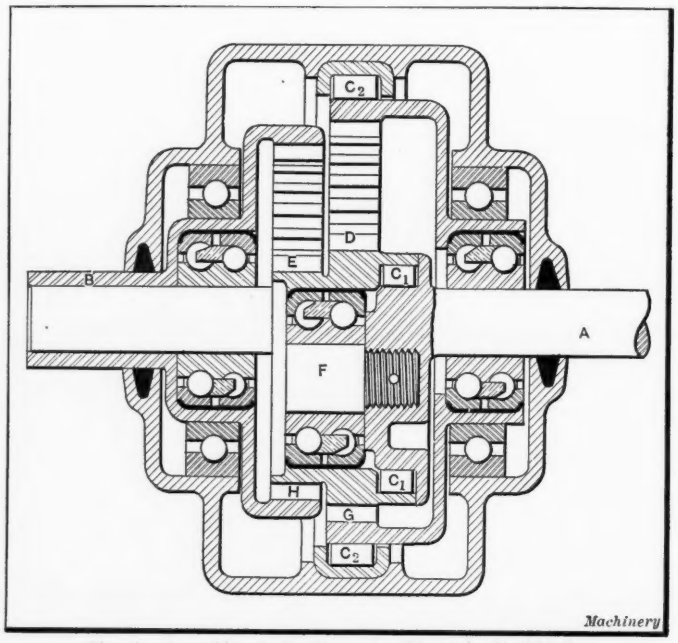

Fig. 4. Assembly of the Four-gear Eccentric Combination

The sign of $\frac{1}{18}$ must be positive in order to have B rotate in the right-hand direction. In the selection of gears for such a combination, it is customary to have a difference of 15 teeth on the gears that mesh, in order to avoid the use of special teeth. From the fraction $\frac{17}{18}$, it is found that a suitable combination is as follows:

$$X = 1 - \frac{51 \times 30}{45 \times 36} = + \frac{1}{18}$$

As an example of the flexibility of the velocity ratio, we will assume: $E = 35$ teeth $= d$; $H = 49$ teeth $= c$; $D = 36$ teeth $= b$; $G = 50$ teeth $= a$.

This gives a velocity ratio of 126 to 1. The flexibility of the velocity ratio is an important advantage of this mechanism because it makes its application possible on practically any mechanical device in which large speed reductions are necessary.

* * *

BROACHING AUTOMOBILE PARTS

BY CHESTER L. LUCAS*

The operation of broaching is too often viewed in the light of a process used principally for cutting keyways or square holes, but with proper equipment the broaching machine is really a machine tool capable of handling a great many otherwise impracticable jobs. Incident to the manufacture of automobile parts there are several interesting broaching operations carried on in the shops of the Hartford Automobile Parts Co., Hartford, Conn.

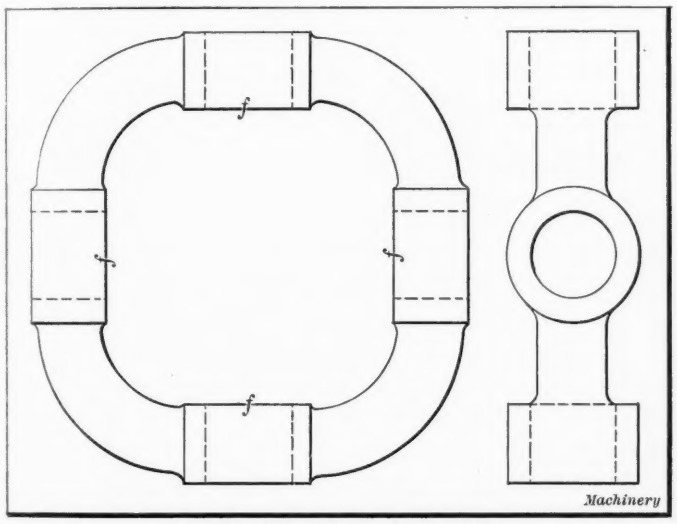

Fig. 1. Ring-coupling to be broached

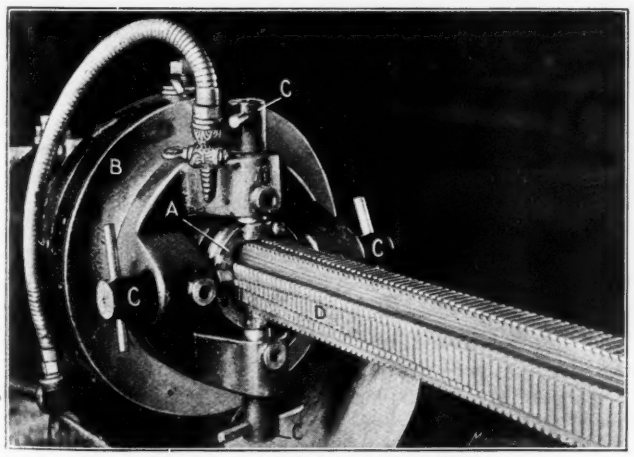

Fig. 2. Broaching the Ring-coupling

One of these jobs consists of broaching the inside of a ring-coupling which is a part of a universal joint made by the company. The ring-coupling, which is shown by itself in Fig. 1, has been previously drilled and broached through the four round holes and as it is essential that the inside faces, adjacent to the four holes be finished true with the holes, broaching is resorted to. In order to accomplish this successfully, the work is held upon a special fixture, in turn mounted upon the faceplate of a broaching machine made by the Lapointe Machine Tool Co., Hudson, Mass. Fig 2 illustrates the method of holding and broaching the work. In this illustration the work is shown at A supported on the

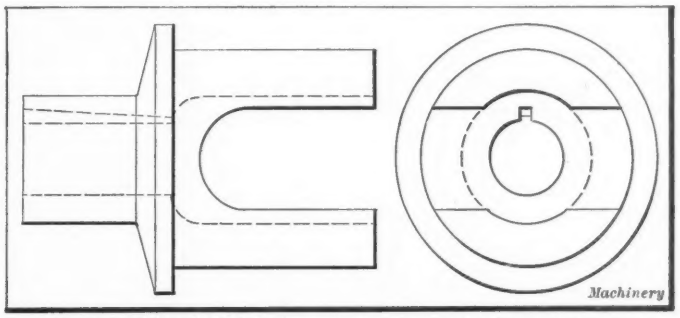

Fig. 3. Universal Joint Yoke to be broached with Tapered Keyway

fixture B by means of four pins C which engage the holes in the coupling. These pins are merely a sliding fit through the bosses of the fixture, and the cross handles are added to assist in withdrawing them. The broach itself is shown at D and is pulled through the work in the usual manner. In order to facilitate the centering of the broach in the work as well as to distribute the cutting over the length of the broach, the cutting surfaces of the teeth are made very narrow at the beginning of the tool, gradually increasing in width until at the end of the work they are full width, finishing the entire surface. These pieces are broached at

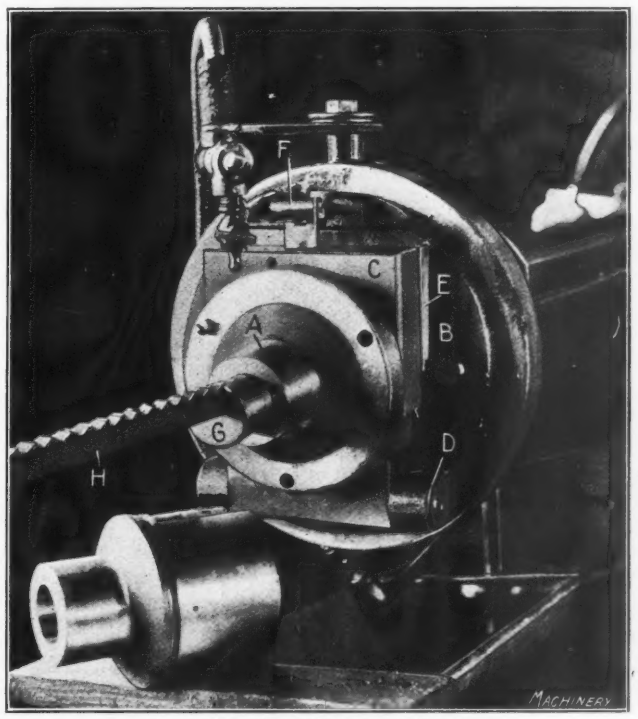

Fig. 4. Broaching the Tapered Keyway

the rate of twenty-five per hour, the surfaces are finished true with the holes and, of course, the sizing is accurate.

Cutting the tapered keyway through the yoke shown in Fig. 3 is a broaching operation that has some interesting features. The keyway must be cut through the bore of the work at an angle of ten degrees. The cut is 5/16 inch deep at the beginning and only 5/32 inch deep at the end of the cut. The method of doing the work is illustrated in Fig. 4 in which the yoke is shown lying in the foreground and again on the machine at A. It is supported on the special fixture B which consists of a faceplate provided with a leaf C that is hinged at D. This leaf is held in an upright position by a clamp F and the work A fits closely in the bushing in the leaf C. As the broaching must be done at an angle to the machined hole the leaf of the fixture is not held at right

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angles to the broach, but is backed up by a tapered wedge *E* so that the work is thrown off at an angle to the broach. When broaching, the work is placed in the leaf of the fixture and the tapered plug *G* is entered into the hole around the broach *H*. This plug is cut out to receive the broach, and serves as a "filler," preventing the broach from springing away from the work. The broaching is then carried on in the usual manner. When broaching must be done at a different angle it only requires the substitution of a wedge of a different angle, in place of wedge *E*. Thus the fixture can be used on more than one job. This broaching operation is performed at the rapid rate of thirty-three pieces per hour.

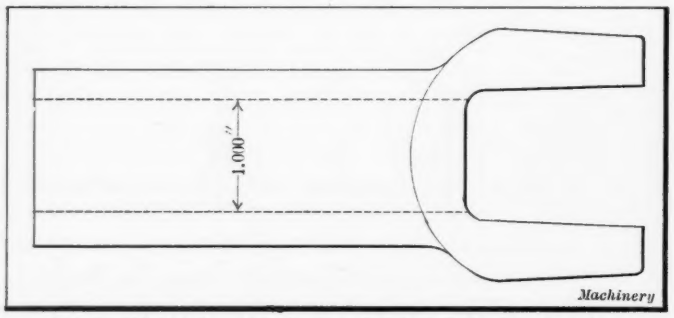

Fig. 5. Slip-hub in which the Round Hole is finished by broaching

The universal slip-hub shown in Fig. 5 is first rough-drilled throughout its length. It is necessary, however, that this hole be finished true to size and exactly in line with the projections at the end. This is accomplished by broaching, as shown in Fig. 6, and in this illustration the piece may be seen lying beneath the fixture. The fixture which is shown at *A* has a leaf *B* provided with an adjustable bushing *C*. The leaf is dropped and the work placed within the fixture so that the projecting lugs are centered. Then replacing the leaf, securing it with pin *G*, and screwing the bushing up against the work so that the countersunk inner end will engage the piece from the outside edge, it is held in a central position ready for broaching. The broach is then inserted and one pass finishes the piece, leaving it exactly to size and finished as smooth as if done with a reamer. Twenty-five broached pieces per hour is the rate of production.

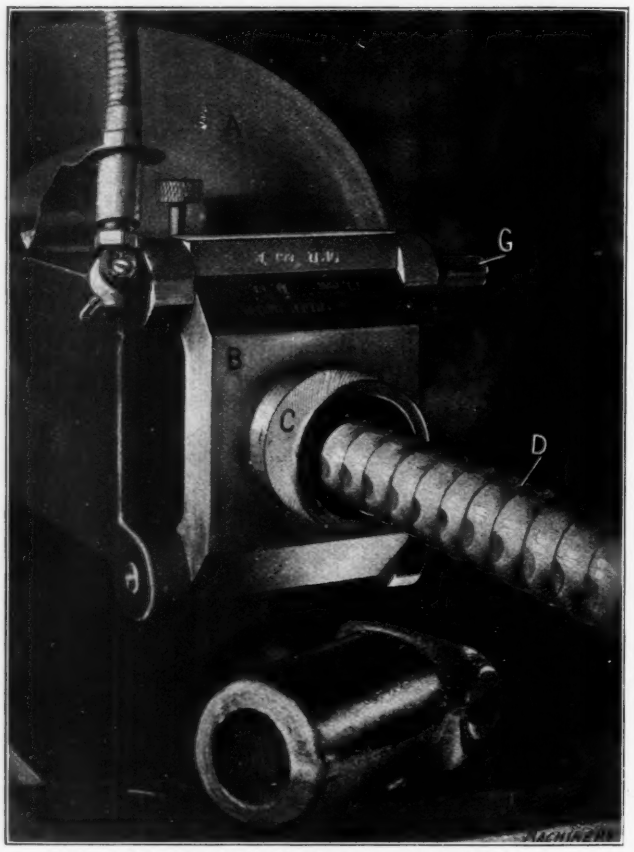

Fig. 6. The Broaching Fixture for the Slip-hub

THE PRECISION LATHE AS A MANUFACTURING MACHINE

The illustration Fig. 1 shows a precision bench lathe made by the Elgin Tool Works, Elgin, Ill., and used by the Aurora Automatic Machine Co., of Aurora, Ill., in the manufacture of motorcycle parts, finishing driving shafts, etc., as they come from the automatic screw machines. The part shown in Fig. 2 is an example. The piece is roughed out in the automatic, leaving 1/32 inch stock on the sides. It is finish-turned all over in the bench lathe at the rate of eleven per hour. The same work was formerly done in an engine lathe at the rate of five per hour. The chip pile shown behind the lathe is the accumulation of four days' work. The company makes a number of brass bushings for motorcycles, and has reduced the cost of their manufacture in about the same proportion as indicated above, by the use of bench lathes.

Fig. 1. Elgin Tool Works Co.'s Precision Lathe working on Motorcycle Parts

Many manufacturers are not fully aware of the possibilities of bench lathes as economical adjuncts in manufacturing, especially where close limits of size and smooth finish are required on parts ordinarily produced by automatic machines. An expert workman can manipulate these lathes at astonishing speeds when reducing parts to finished dimensions, especially when several diameters are involved and some of the faces are angular, as for example, in the case of small bevel-gear blanks.

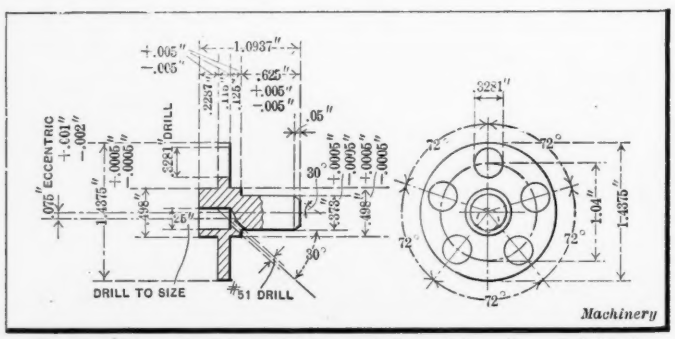

Fig. 2. Motorcycle Driving Shaft roughed on Automatic and finished on Precision Lathe

* * *

INSTRUCTION IN ACCIDENT PREVENTION

The State of New Jersey has enacted a law providing for instruction in preventing accidents. The law provides that the teachers of public, private and parochial schools in New Jersey shall devote not less than thirty minutes in each two weeks during the school terms to instructing the pupils on ways and means of preventing accidents. It also provides that a handbook or manual on accident prevention shall be published by the state, and provision is made for the delivery of lectures before the schools by representatives of the American Museum of Safety, the headquarters of which is at 29 W. 39th St., New York City.

MACHINE FORGING—3

MACHINES AND METHODS EMPLOYED IN THE MANUFACTURE OF BOLTS, RIVETS, NUTS, MACHINE PARTS, ETC.

BY DOUGLAS T. HAMILTON*

The plain type of upsetting and forging machine which is used to a certain extent in the manufacture of bolts and rivets, especially the larger sizes, is also used for producing the ordinary square and hexagon nuts in sizes from 2 inches up. In making nuts by this process, the diameter of the round bar from which the nut is made should not exceed the root diameter of the thread in the finished nut, so it is evident that an extremely large upset is required to produce a full nut. When large nuts are produced in a plain forging machine, the usual method is first to form an upset on the end of the bar and then pierce the hole in the nut by punching the bar back, the metal removed to form the hole in the nut being attached to the bar. This operation requires considerable pressure, and as little, if any, material is wasted it is a very successful method of producing nuts 2 inches and larger on a commercial basis. The application of upsetting and forging machines to the production of other than the ordinary square and hexagon nuts will be dealt with in a future article. In the following, two types of machines, especially built to produce square and hexagon nuts, will be described. One of these machines is known as the hot-pressed center-feed nut machine, and the other as the hot-forged type; the latter is applicable only to the production of square nuts. This article will also include tables and other data used in connection with bolt and nut making.

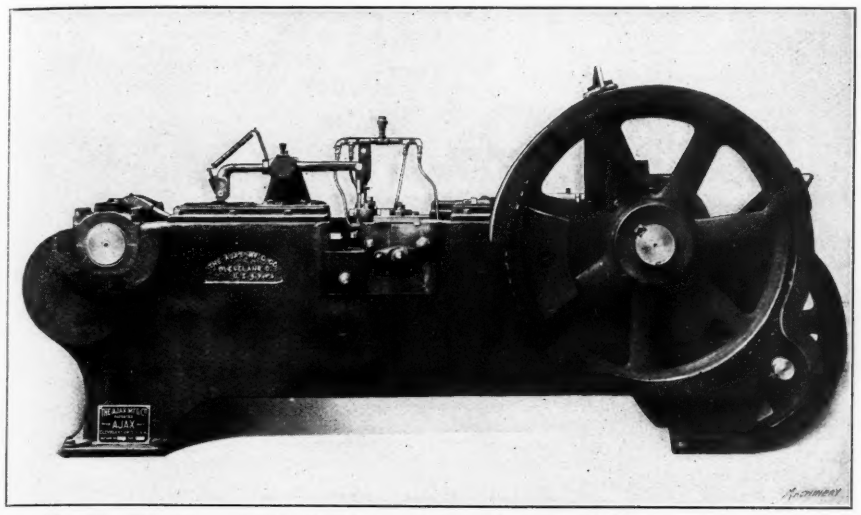

Fig. 35. Side View of "Ajax" Hot-pressed Center-feed Nut Machine showing Operating Side and Water Pipes for cooling Dies and Tools

Hot-pressed Center-feed Nut Machine

The hot-pressed center-feed nut machine, as its name implies, produces nuts by pressing a heated blank of iron or steel into the required shape (the latter first being cut off as the bar is fed into the machine) and not by what might be strictly called a forging operation. The bar stock, which is rectangular in shape, is fed in and placed in front of the face of the dies from the side through a recess in the center of the machine. Fig. 35 shows one type of center-feed hot-pressed nut machine that works on the principle just stated. This machine consists essentially of two movable rams or slides which carry the cutting-off, crowning, piercing and wad-extracting punches, respectively. One ram is operated directly from the main crankshaft, while the other is operated by eccentrics and a connecting-rod.

Fig. 36 shows a closer view of this machine, and gives some idea of the construction of the dies, tools, etc. Here *A* is the cutting-off punch, *B* the crowning punch, *C* the piercing punch, *D* the wad extractor, *E* the nut dies, and *F* the ejector. The pipes *G* furnish a copious supply of water to keep the dies and tools cool when in operation. A device for centering the bar in relation to the dies and tools is shown at *H*.

Another center-feed hot-pressed nut machine, which produces hexagon and square nuts in the same manner as that shown in Fig. 35, is shown in Fig. 37. In this machine, however, both rams or slides are operated directly from the source of power by a pinion and two large gears, one gear driving each slide. The majority of manufacturers produce nuts from a material known as soft, mild, open-hearth steel, which has a comparatively fine grain and consequently when forged has less tendency to crack than does wrought iron. It also threads much easier and with a smooth finish. This grade of steel is much more suitable for the manufacturing of nuts than wrought iron, owing to the fact that great difficulty is met with in working the latter material, as the grain opens up, thus making it difficult to thread. Wrought iron, however, has one point in its favor, and that is it can be worked at a much higher temperature than steel without affecting its structure, and hence does not need to be handled quite so carefully.

Operation of a Center-feed Hot-pressed Nut Machine

In operating a center-feed hot-pressed nut machine, the rectangular bar is heated to the correct temperature for a length of four or five feet. Then it is brought to the machine and fed in from the side in front of the face of the main dies, as indicated at *A* in Fig. 38. The cut-off tool *c* then moves up and

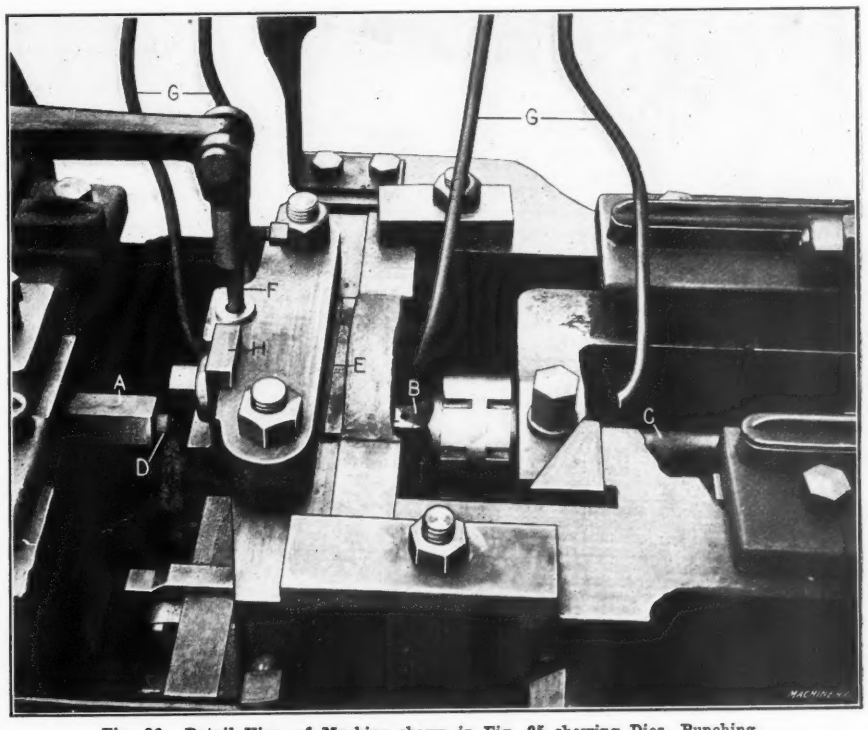

Fig. 36. Detail View of Machine shown in Fig. 35 showing Dies, Punching, Piercing, Crowning Tools, etc.

shears the blank from the end of the bar, carries it into the main dies *a* and *b*, and presses it against the crowning tool *e*, which has also advanced, as indicated at *B*. The piercing tool *f* now advances, punches the hole in the nut, and carries the wad into the cutting-off tool, as shown at *C*. Then the cutting-off and piercing tools *c* and *f* recede, and the crowning tool *e* advances, forcing the nut out of the dies. As the cut-off

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tool *c* recedes, the extractor *d* forces the wad out of the punch at the same time that the nut is ejected from the dies. The ejector, which is operated by a lever and cam, as shown in Fig. 37, is provided to prevent the nut from adhering to the crowning tool; this very seldom happens, however. A completed nut is produced at each revolution of the large gears.

The operations just described are repeated until the heated portion of the bar has been exhausted, after which the operator places the bar in the furnace to be reheated, takes a freshly heated bar from the furnace, and proceeds as before. The machine is run continuously, and is not stopped for the insertion of a freshly heated bar. Finished nuts are turned out at the rate of from 40 to 70 per minute, depending upon the size of the machine and the skill of the operator. Fig. 39 shows how a hexagon nut is produced from a rectangular bar of stock in a center-feed hot-pressed nut machine. Upon a close inspection of this illustration, it will be seen that considerable scrap is lost in the production of a nut of hexagon shape, *viz.*, the wad removed to form the hole, and the triangular pieces which are removed to form the corners. On a square nut the material wasted is not quite so great, as in this case only the wad and a slight amount of stock sheared off the end of the bar to form a square corner are removed.

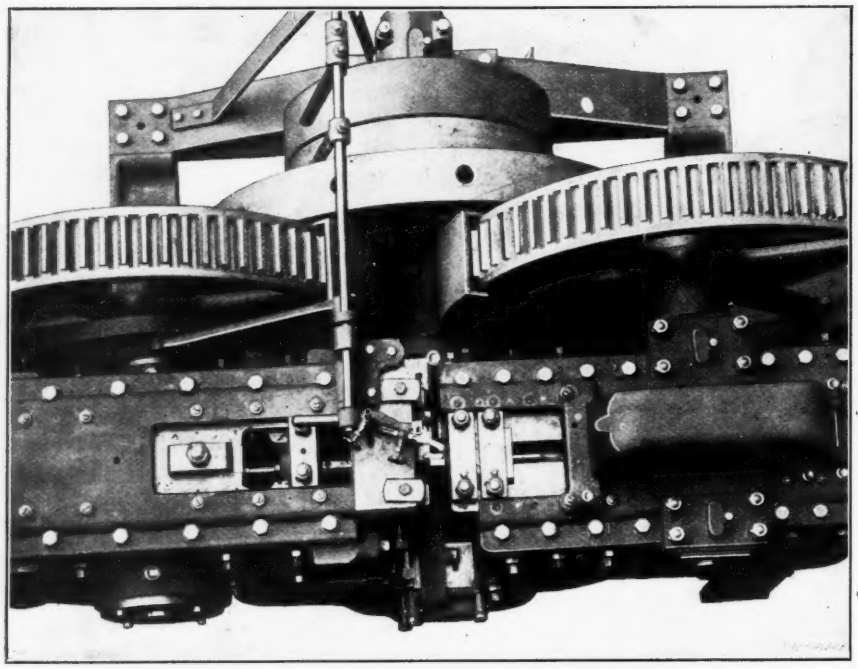


Fig. 37. Top View of "National" Hot-pressed Center-feed Nut Making Machine

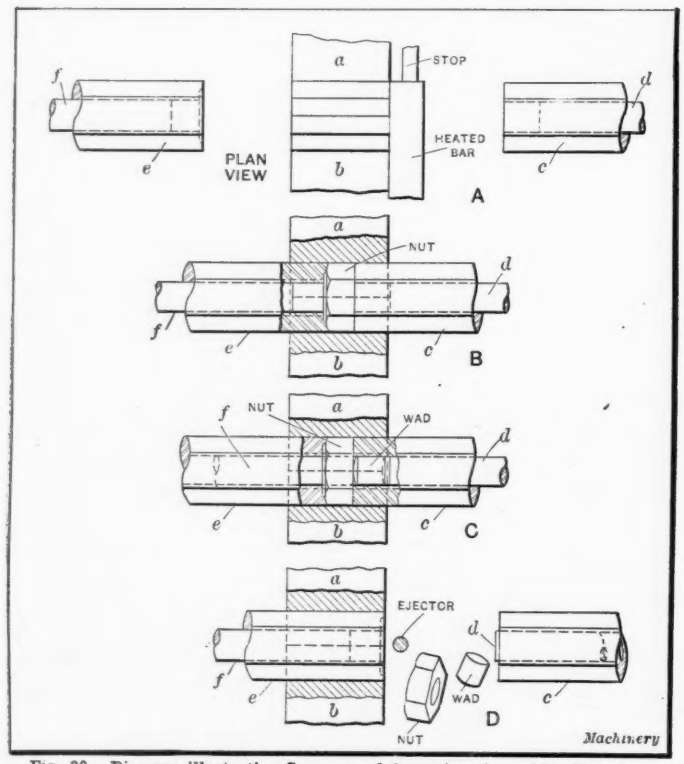


Fig. 38. Diagram illustrating Sequence of Operations in making Nuts in a Hot-pressed Center-feed Nut Machine

There are two common methods of saving stock without sacrificing the shape of the nut. One is to set the stop so that the rounded end of the bar is sheared off, leaving a square corner. This, of course, wastes a little more stock, but has the advantage of producing a fuller nut. The rounded corner is caused by the cut-off tool, which in removing the block of metal from the end of the bar to form the nut, rounds over the end of the bar due to the hot metal drawing over, and thus makes this waste of stock necessary if a full-shaped nut is to be secured.

Another method in common use to save stock and at the same time produce full nuts, is to invert the bar after each stroke of the machine. By this method opposite sides of the bar are alternately presented to the dies, which overcomes, to a large extent, the effect of the fin on one side and the rounded corner on the other, and produces a fuller nut without shearing any material from the end of the bar. The only objection to this method is the necessity of turning the bar, which, if heavy, soon tires the operator. On the larger sizes of nuts, the first method is used, as the bars are quite heavy and the operator would find it difficult to turn them and keep up with the operation of the machine.

Fig. 40 shows a typical group of nuts which can be produced economically and on a commercial basis in the center-feed hot-pressed nut machines. In this illustration it will be noticed that several of the nuts have fins on the under side, both around the outer edges and hole. This is caused by the sharp edges of the cut-off tool becoming rounded and allowing the hot metal to "leak" past the edges. The clearance allowed between the cut-off punch and dies also tends to produce a slight fin. When the tools are new the burr or fin produced is very slight, but it increases as the tools wear. These fins are removed in a succeeding operation in a burring machine, which will be described in a future article.

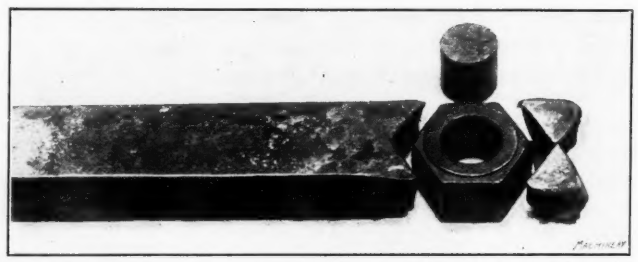


Fig. 39. Showing how a Hexagon Nut is produced from Rectangular Bar in a Hot-pressed Nut Machine

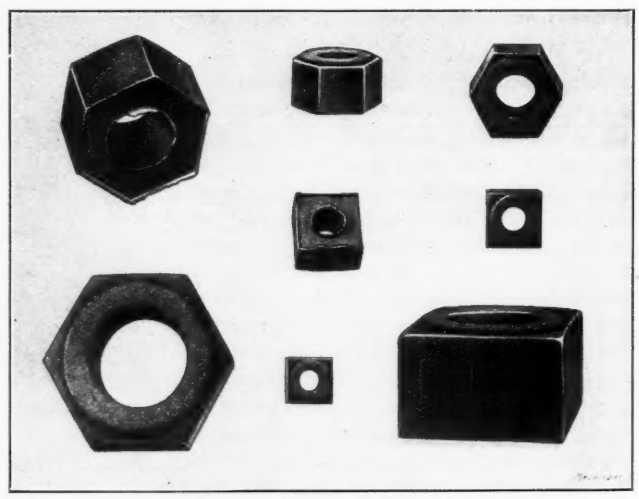


Fig. 40. Group of Square and Hexagon Nuts, showing Character of Work turned out in Hot-pressed Nut Machines

Hot-forged Nut Machine

Fig. 41 shows a type of nut making machine which is only applicable to the manufacture of square nuts, but produces this class of nuts free from fins and burrs at a rapid rate. Large nut manufacturers are extensive users of this type of machine,

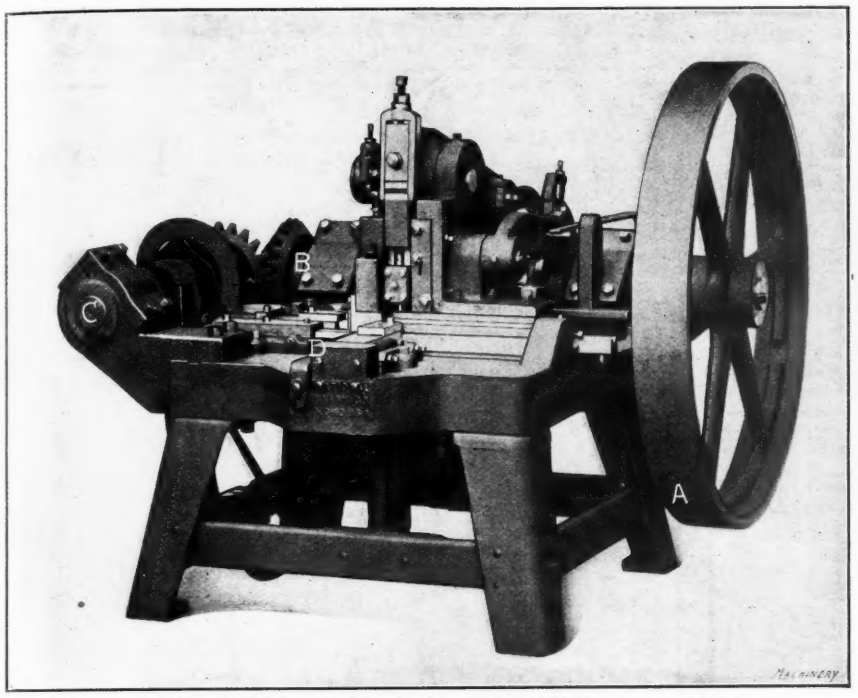


Fig. 41. "National" Hot-forged Nut Machine used exclusively for the Manufacture of Square Nuts from Rectangular Bar Stock

but a concern making a variety of nuts in small quantities would not attempt to use it, owing to the delay incident to changing the dies and tools from one size to another. Briefly stated, it consists principally of a suitable mechanism for operating a shearing and crowning tool, four horizontal hammers which form the four sides of a square nut, and piercing and flattening punches. Power is received by the pulley *A* and is transmitted to the two shafts *B* and *C* located at right angles to each other and connected by miter gears. Shaft *C* carries eccentrics and cams which operate the left-side hammer and sizing tool for gripping the bar while it is being sheared; and shaft *B*, through cams, levers and eccentrics, operates the blank shearing tool, nut ejector, front and rear hammers, piercing punch and flattening tools.

Operation of Hot-forged Nut Machine

In order to illustrate how this hot-forged nut machine produces square nuts, the diagrams shown in Fig. 42 are included. These views show plan and sectional elevations which illustrate the relative positions of the various dies and tools, and the stages through which the nut passes before being ejected. In operating this machine, rectangular bar stock heated to a length of four or five feet is fed into the machine (see *D*, Fig. 41), along the line *C*—*D*. The stock is equal in width to the diameter of the nut across the flats, and of the same thickness as the nut. It is fed into the machine with the greatest width horizontal and is located by the gage *G*.

As the heated bar is fed in, a shearing tool *H* operated from the bottom of the machine, forces the heated end of the bar against the knife *K* and cuts off a suitable blank; as this tool continues to rise, it presses the nut blank into the crowner cup *M*, which is located directly above the shearing tool. While the shearing operation is taking place, the sizing tool *I*, which moves in a line parallel with the side hammer *J*, holds the bar tightly against the stationary sizer *K*. Gripping the bar in this manner tends to give a better shearing cut. The shearing tool *H* is now lowered until its top face is in line with the bottom of the side hammer *J*, and at the same time the kickout *N*, operated through a hole in the crowner *M*, ejects the nut, preventing it from sticking in the cup. The shearing tool now remains in its "down" position while the side hammer *J* carries the nut along the line *A*—*B* until the center of the nut is in line with *E*—*F* and directly under the piercing punch *O*.

As the side hammer *J* moves the nut blank under the piercing punch, the rear hammer *P* advances and presses the nut into the square box formed by the side hammer *J*, rear hammer *P*, stationary hammer *R* and front hammer *Q*. This tends to square up the sides of the nut and form it to the proper shape. While in this position, the punch *O* pierces the hole in the nut, forcing the wad through the die *V*, and immediately withdraws. The rear hammer *P* and side hammer *J* then return to their original positions, and the front hammer *Q* moves the nut back to the flatter bed *T*, which is located directly under the rear hammer *P*. While the nut is located on the flatter bed, the flattening tool *U*, which is over the rear hammer, comes down onto the nut, gives it a slight squeeze, which corrects any distortion of the top and bottom faces caused by the squeezes between the four hammers previously described, and also serves to flatten any fins resulting from the piercing operation. The flattening tool *U* then rises, and the flatter bed *T* withdraws, allowing the finished nut to drop out of the machine. A completed nut is made at each revolu-

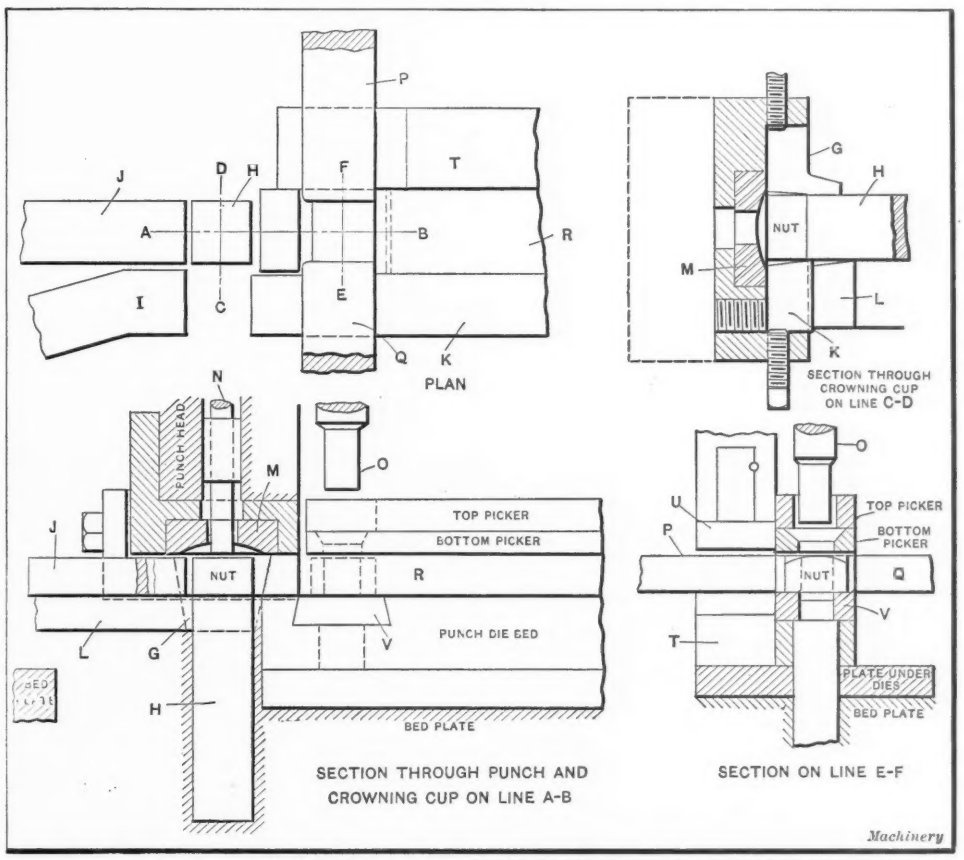


Fig. 42. Diagrams illustrating Construction of Tools and Operation of the Hot-forged Type of Nut Machine shown in Fig. 41

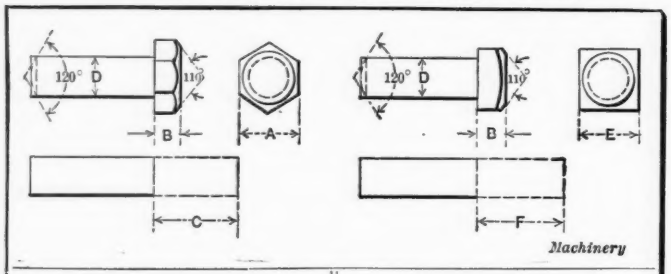
tion of the flywheel, and the machine is operated at from 60 to 90 revolutions per minute, depending upon its size.

Some idea of the character of the work turned out by the hot-forged nut machine can be obtained from Fig. 43, which shows a representative group of square nuts just as they come from the machine. The nuts produced by these machines are entirely free from fins or burrs, are of excellent finish, and are ready for tapping directly after being forged.

Dies and Tools Used in Hot-pressed Center-feed Nut Machines

The type of dies and tools used in the hot-pressed center-feed nut machine shown in Fig. 37 is shown in Fig. 44. To obviate confusion the reference letters used here are the same as those given in Fig. 38. The dies *a* and *b*, which are reversible, are usually made from chilled iron castings, and are ground to size. Dies made from this material, it is claimed, will last fully eight times as long as those made from ordinary carbon steel, but as it is somewhat of a problem to get the proper amount of "chill," many manufacturers use a good grade of open-hearth crucible steel instead. A crucible steel which has been found to give good results for this class of work contains from 90 to 110 points carbon. Some nut manufacturers have found that a certain grade of high-speed steel having a carbon content of from 15 to 30 points gives excellent results when used for nut dies. In all cases, of course, it is necessary to harden the dies, and those made from crucible tool steel are hardened and drawn so that they can just be touched with the file, or in other words, the temper is drawn to a light straw color.

TABLE I. PROPORTIONS OF U. S. STANDARD AND MANUFACTURERS' STANDARD HEXAGON AND SQUARE HEAD BOLTS AND APPROXIMATE AMOUNT OF STOCK REQUIRED TO FORM HEAD

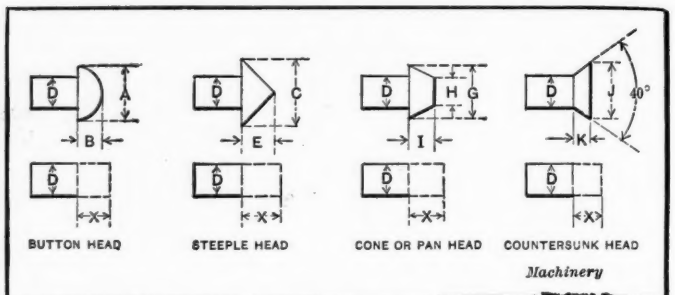


United States Standard — Dimensions in Inches						Manufacturers' Standard — Dimensions in Inches					
D	A	B	C	E	F	D	A	B	C	E	F
¼	7/16	3/16	1 3/32	½	1 9/32	¼	7/16	3/16	23/32	5/8	17/32
5/16	35/64	15/64	1 1/8	9/16	1 5/16	5/16	17/32	¼	29/32	25/32	1 1/16
3/8	21/32	9/32	1 1/4	11/16	1 7/16	3/8	5/8	9/32	1	15/16	1 3/16
7/16	49/64	5/16	1 3/8	25/32	1 1/2	7/16	23/32	21/64	1 1/8	1 1/16	1 5/16
½	7/8	11/32	1 1/2	7/8	1 9/32	½	13/16	3/8	1 1/4	1 3/16	1 7/16
9/16	1	25/64	1 5/8	31/32	1 11/16	9/16	29/32	27/64	1 3/8	1 5/16	1 1/2
5/8	1 1/16	7/16	1 3/4	1 1/16	2	5/8	1	15/32	1 1/2	1 7/16	1 5/8
11/16	1 1/8	31/64	1 7/8	1 1/8	2 3/32	11/16	1 1/16	17/32	1 5/8	1 9/16	1 11/16
¾	1 7/16	⅜	2	1 7/32	2 7/32	¾	1 1/8	19/32	1 3/4	1 11/16	1 13/16
13/16	1 5/16	23/64	2 1/8	1 5/16	2 5/16	13/16	1 3/16	5/8	1 7/8	1 13/16	1 15/16
⅞	1 7/16	25/64	2 1/4	1 3/8	2 1/2	⅞	1 1/4	21/32	2	1 15/16	2 1/16
15/16	1 1/2	27/64	2 3/8	1 7/16	2 11/16	15/16	1 5/16	11/16	2 1/8	2	2 3/16
1	1 5/8	7/16	2 1/2	1 1/2	2 7/8	1	1 3/8	¾	2 1/4	2 1/16	2 5/16
1 1/16	1 11/16	29/64	2 5/8	1 9/16	3 1/16	1 1/16	1 7/16	25/32	2 3/8	2 1/8	2 7/16
1 1/8	1 3/4	15/32	2 3/4	1 5/8	3 1/4	1 1/8	1 1/2	27/32	2 1/2	2 3/16	2 9/16
1 3/16	1 13/16	31/64	2 7/8	1 11/16	3 7/16	1 3/16	1 9/16	29/32	2 5/8	2 5/16	2 11/16
1 ¼	1 7/8	½	3	1 3/4	3 5/8	1 ¼	1 5/8	15/16	2 3/4	2 7/16	2 13/16
1 5/16	1 15/16	33/64	3 1/8	1 13/16	3 13/16	1 5/16	1 11/16	1	2 7/8	2 1/2	2 15/16
1 ⅜	2	17/32	3 1/4	1 7/8	4	1 ⅜	1 ¾	1 1/32	3	2 5/8	3 1/16
1 7/16	2 1/16	35/64	3 3/8	1 15/16	4 3/16	1 7/16	1 13/16	1 1/16	3 1/8	2 3/4	3 3/16
1 ½	2 1/8	9/16	3 1/2	2	4 3/8	1 ½	1 7/8	1 3/32	3 1/4	2 7/8	3 5/16
1 9/16	2 3/16	37/64	3 5/8	2 1/16	4 9/16	1 9/16	1 15/16	1 5/32	3 3/8	2 15/16	3 7/16
1 ⅝	2 ¼	19/32	3 3/4	2 1/8	4 11/16	1 ⅝	2	1 7/32	3 1/2	3	3 9/16
1 11/16	2 5/16	39/64	3 7/8	2 3/16	4 13/16	1 11/16	2 1/16	1 9/32	3 5/8	3 1/16	3 11/16
1 ¾	2 3/8	5/8	4	2 ¼	5	1 ¾	2 1/8	1 11/32	3 3/4	3 1/8	3 13/16
1 13/16	2 7/16	41/64	4 1/8	2 5/16	5 1/8	1 13/16	2 3/16	1 13/32	3 7/8	3 3/16	3 15/16
1 ⅞	2 ½	21/32	4 1/4	2 3/8	5 5/16	1 ⅞	2 ¼	1 15/32	4	3 ¼	4 1/8
1 15/16	2 9/16	43/64	4 3/8	2 7/16	5 7/16	1 15/16	2 5/16	1 17/32	4 1/8	3 5/16	4 5/16
2	2 5/8	11/16	4 1/2	2 ½	5 9/16	2	2 3/8	1 19/32	4 1/4	3 3/8	4 7/16
2 ¼	2 13/16	¾	4 5/8	2 11/16	5 13/16	2 ¼	2 7/8	1 23/32	4 5/8	3 13/16	4 15/16
2 ½	3 1/16	13/16	4 3/4	2 13/16	6 1/16	2 ½	3 1/16	1 27/32	4 7/8	4 1/16	5 3/16
2 ¾	3 5/16	⅞	4 7/8	2 15/16	6 5/16	2 ¾	3 5/16	1 31/32	5 1/8	4 5/16	5 7/16
3	3 9/16	15/16	5	3 1/16	6 9/16	3	3 9/16	2 1/32	5 3/8	4 9/16	5 11/16
3 ¼	3 7/8	1	5 1/8	3 3/16	6 13/16	3 ¼	3 7/8	2 5/32	5 5/8	4 13/16	5 15/16
3 ½	4 3/16	1 1/16	5 1/4	3 5/16	7 1/16	3 ½	4 3/16	2 9/32	5 7/8	5 1/16	6 3/16
3 ¾	4 ½	1 1/8	5 3/8	3 7/16	7 5/16	3 ¾	4 ½	2 13/32	6 1/8	5 5/16	6 7/16
4	4 ¾	1 3/16	5 ½	3 ½	7 9/16	4	4 13/16	2 17/32	6 3/8	5 9/16	6 11/16

The cut-off tool *c* is generally made from ordinary carbon tool steel, hardened and drawn. Some attempts have been made to use high-speed steel for this tool, but as this material is rather expensive, and as this particular tool wears away very rapidly, a cheaper brand of steel is generally adopted. The piercing tool *f* when made from "Rex A" high-speed steel has been found very satisfactory for hot punching. The crowning tool *e* and wad extractor *d* can be made from ordinary carbon tool steel, hardened and drawn.

In order that the tools in a center-feed hot-pressed nut machine may work freely, it is necessary to provide a certain amount of clearance, especially between the cut-off tool, crowning tool and dies. On ordinary sizes of nuts from ½ to 2 inches in diameter (this is the size of the bolt for which the nut is used), 1/64 inch clearance is allowed. On sizes smaller than ½ inch, 0.010 inch clearance is allowed, whereas for tools used in making nuts larger than 2 inches, a clearance of from 0.020 to 0.060 inch is provided. The hole formed by the junction of the two halves of the dies is made perfectly straight, but the piercing tool is slightly tapered — being smaller at the front end. This enables it to withdraw more easily from the hole in the nut, and also increases its life. It is evident, of course, that after the hole is punched in the nut, the chilling effect of the dies (which are kept cool by water flowing over them), tends to "freeze" the nut onto the piercing tool, and the slight taper on the piercing tool obviates this.

TABLE II. DIMENSIONS OF RIVET HEADS OF VARIOUS SHAPES



Dimensions in Inches									
D	A	B	C	E	G	H	I	J	K
¼	7/16	3/16	½	¼	7/16	¼	7/32	29/64	⅛
5/16	35/64	15/64	5/8	5/16	35/64	5/16	17/64	37/64	5/32
⅜	21/32	9/32	¾	⅜	21/32	⅜	21/64	11/16	3/16
7/16	49/64	5/16	⅞	7/16	49/64	7/16	¼	43/64	7/32
½	7/8	⅜	1	½	7/8	½	9/32	3/4	¼
9/16	1	27/64	1 1/8	9/16	1	9/16	5/16	1 1/32	9/32
⅝	1 1/32	15/32	1 1/4	⅝	1 1/32	⅝	11/32	1 5/32	5/16
11/16	1 1/8	½	1 3/8	11/16	1 1/8	11/16	23/64	1 1/8	11/32
¾	1 7/32	17/32	1 1/2	¾	1 7/32	¾	25/64	1 13/64	3/8
13/16	1 5/16	19/32	1 5/8	13/16	1 5/16	13/16	27/64	1 5/32	13/32
⅞	1 13/32	5/8	1 3/4	⅞	1 13/32	⅞	29/64	1 13/64	7/16
15/16	1 1/2	21/32	1 7/8	15/16	1 1/2	15/16	15/32	1 9/32	15/32
1	1 9/16	11/16	2	1	1 9/16	1	½	1 5/16	½
1 1/16	1 5/8	¾	2 1/8	1 1/16	1 5/8	1 1/16	17/32	1 3/8	17/32
1 ⅛	1 11/16	23/32	2 1/4	1 ⅛	1 11/16	1 ⅛	9/16	1 7/16	9/16
1 ¼	1 13/16	25/32	2 3/8	1 ¼	1 13/16	1 ¼	19/32	1 1/2	19/32
1 ⅜	1 15/16	27/32	2 1/2	1 ⅜	1 15/16	1 ⅜	5/8	1 9/16	5/8
1 ½	2	29/32	2 5/8	1 ½	2	1 ½	21/32	1 5/8	21/32

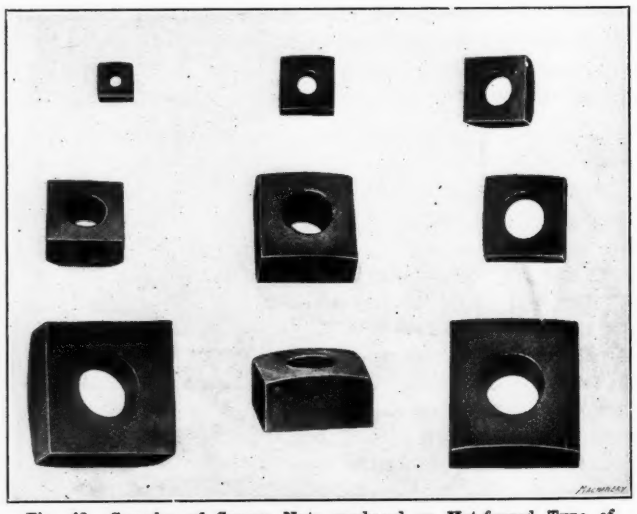


Fig. 43. Samples of Square Nuts produced on Hot-forged Type of Nut Machine—Note Absence of Burrs or Fins

There is no allowance made in the hole of the nut to provide for shrinkage, as the holes regularly punched in nuts are made considerably larger than the root diameter of the threads on the tap. This enables the nuts to be more easily tapped, and

also increases the tap life. Making the hole in the nut larger than the root diameter of the threads on the tap does not affect the efficiency of the nut, but it does make a great difference in tapping.

In Fig. 45 is shown the shape of the dies used for making square nuts in a center-feed hot-pressed nut machine. It will be noticed that these dies are made in four pieces, and it is possible to raise or lower the outside blocks *A* and *B*, so that new cutting edges are secured. In addition to this the top and bottom dies *C* and *D* can be reversed, and also the two side pieces, thus giving long life to one redressing of the dies. As a rule, this type of dies is made from ordinary crucible tool steel containing from 90 to 100 points carbon, hardened and drawn, and ground all over.

Dies and Tools Used in Hot-forged Nut Machines

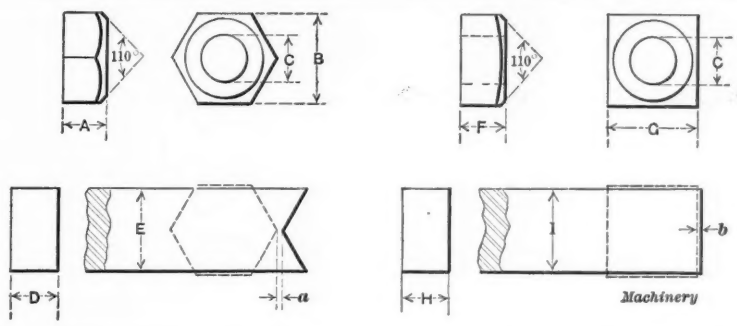
The four hammers used in the hot-forged nut machine are made from rectangular blocks of steel, shaped as shown in Fig. 42. The rear, front and stationary hammers are made wider than the nut, but of approximately the same thickness, and the front and rear hammers are rounded on the forward corners, to facilitate the insertion of the nut. The side hammer, which carries the nut into the "box-shaped impression" formed by all four hammers, is of the same width and thickness as the nut. The crowner, flatter tool and the four hammer blocks are all made from ordinary crucible tool steel, hardened and drawn, whereas the shearing tool and piercing punch and die are usually made from high-speed steel. A brand of steel known as "Rex A" has been found very satisfactory for this purpose. The tools used in the hot-forged nut machine do not wear out nearly so quickly as those used in the hot-pressed type of machine, owing to the fact that there is not the same scraping action against the surfaces of the tools.

Stock Required for Making Bolt and Rivet Heads

In forming a head on a bolt or rivet, the heated metal on the end of the bar is upset or formed into the desired shape by a plunger held in the ram of the forging machine. To produce the head requires considerably more metal than the thickness of the head—because of the increase in diameter—and hence it is necessary to allow a certain amount of excess stock to form the head. Table I gives proportions of U. S. standard and Manufacturers' standard hexagon and square bolt heads, and also the approximate amount of stock required to form the head—this information being listed in Columns "C" and "F." The excess amount of stock given is not exact, but is close enough for starting the machine, as the stop can afterward be adjusted to suit.

In making rivets in a continuous-motion rivet machine, the amount of excess stock required is generally obtained by trial, but of course when definite shapes and proportions of rivet heads have been decided upon, the amount of excess stock required can be calculated approximately. The great difficulty in giving tables covering the amount of excess stock required is that no standard for rivet heads is universally followed, with the result that a slight difference in the curve or height of the head changes the amount of stock necessary. In addition to this, the scale of the furnace, depending upon whether gas, oil or coal is used for heating, so changes the amount of stock required that it necessitates a special setting of the stop in different cases. This is one of the reasons why up-to-date continuous-motion rivet making machines are provided with stops which can be adjusted while the machine is in motion. It is evident, therefore, that the exact amount of stock required is a question of some nicety, and it is surprising to what extent even the scaling off in the furnace will affect the

TABLE III. PROPORTIONS OF U. S. STANDARD AND MANUFACTURERS' STANDARD HEXAGON AND SQUARE NUTS AND SIZES OF RECTANGULAR STOCK REQUIRED TO PRODUCE THEM



United States Standard										Manufacturers' Standard									
Dia. of Bolt	Dimensions in Inches									Dia. of Bolt	Dimensions in Inches								
	A	B	C	D	E	F	G	H	I		A	B	C	D	E	F	G	H	I
1/4	1/4	1/2	13/64	17/64	15/32	1/4	1/2	17/64	15/32	1/4	1/4	1/2	7/32	17/64	15/32	1/4	1/2	17/64	15/32
5/16	5/16	19/32	1/4	11/32	9/16	5/16	19/32	11/32	9/16	5/16	5/16	5/8	9/32	11/32	19/32	5/16	5/8	11/32	19/32
3/8	7/16	11/16	1/4	15/32	13/16	3/8	11/16	15/32	13/16	3/8	7/16	3/4	5/16	15/32	1 3/16	3/8	3/4	15/32	1 3/16
7/16	1/2	25/32	5/16	17/32	1 1/16	7/16	25/32	17/32	1 1/16	7/16	1/2	7/8	7/16	17/32	1 5/16	7/16	7/8	17/32	1 5/16
1/2	9/16	31/32	3/8	19/32	1 3/16	1/2	31/32	19/32	1 3/16	1/2	9/16	1	1/2	19/32	1 7/16	1/2	1	19/32	1 7/16
9/16	5/8	1 1/16	7/16	21/32	1 5/16	9/16	1 1/16	21/32	1 5/16	9/16	5/8	1 1/8	9/16	21/32	1 5/8	9/16	1 1/8	21/32	1 5/8
5/8	3/4	1 1/8	1/2	23/32	1 7/16	5/8	1 1/8	23/32	1 7/16	5/8	3/4	1 1/4	9/16	23/32	1 13/16	5/8	1 1/4	23/32	1 13/16
3/4	7/8	1 5/16	9/16	7/8	1 11/16	3/4	1 5/16	7/8	1 11/16	3/4	7/8	1 7/16	5/8	7/8	2 1/16	3/4	1 7/16	7/8	2 1/16
7/8	1	1 7/16	5/8	1	1 7/8	7/8	1 7/16	1	1 7/8	7/8	1	1 5/8	11/16	1	2 5/16	7/8	1 5/8	1	2 5/16
1	1 1/8	1 9/16	11/16	1 1/8	2 1/16	1	1 9/16	1 1/8	2 1/16	1	1 1/8	1 13/16	3/4	1 1/8	2 9/16	1	1 13/16	1 1/8	2 9/16
1 1/8	1 1/4	1 3/4	3/4	1 1/4	2 5/16	1 1/8	1 3/4	1 1/4	2 5/16	1 1/8	1 1/4	2	7/8	1 1/4	2 13/16	1 1/8	2	1 1/4	2 13/16
1 1/4	1 3/8	1 15/16	13/16	1 3/8	2 3/4	1 1/4	1 15/16	1 3/8	2 3/4	1 1/4	1 3/8	2 3/16	15/16	1 3/8	3 1/16	1 1/4	2 3/16	1 3/8	3 1/16
1 3/8	1 1/2	2 3/16	15/16	1 1/2	3 1/16	1 3/8	2 3/16	1 1/2	3 1/16	1 3/8	1 1/2	2 3/8	1	1 1/2	3 5/16	1 3/8	2 3/8	1 1/2	3 5/16
1 1/2	1 5/8	2 3/8	1 1/16	1 5/8	3 5/16	1 1/2	2 3/8	1 5/8	3 5/16	1 1/2	1 5/8	2 9/16	1 1/16	1 5/8	3 1/2	1 1/2	2 9/16	1 5/8	3 1/2
1 5/8	1 3/4	2 9/16	1 1/8	1 3/4	3 1/2	1 5/8	2 9/16	1 3/4	3 1/2	1 5/8	1 3/4	2 3/4	1 1/8	1 3/4	3 11/16	1 5/8	2 3/4	1 3/4	3 11/16
1 3/4	1 7/8	2 3/4	1 3/16	1 7/8	3 11/16	1 3/4	2 3/4	1 7/8	3 11/16	1 3/4	1 7/8	2 15/16	1 3/16	1 7/8	3 7/8	1 3/4	2 15/16	1 7/8	3 7/8
1 7/8	2	2 15/16	1 1/4	2	3 7/8	1 7/8	2 15/16	2	3 7/8	1 7/8	2	3 1/8	1 1/4	2	4 1/16	1 7/8	3 1/8	2	4 1/16
2	2 1/8	3 1/8	1 5/16	2 1/8	4 1/16	2	3 1/8	2 1/8	4 1/16	2	2 1/8	3 5/16	1 5/16	2 1/8	4 5/16	2	3 5/16	2 1/8	4 5/16
2 1/4	2 3/8	3 5/16	1 7/16	2 3/8	4 5/16	2 1/4	3 5/16	2 3/8	4 5/16	2 1/4	2 3/8	3 1/2	1 7/16	2 3/8	4 1/2	2 1/4	3 1/2	2 3/8	4 1/2
2 1/2	2 5/8	3 1/2	1 1/2	2 5/8	4 1/2	2 1/2	3 1/2	2 5/8	4 1/2	2 1/2	2 5/8	3 11/16	1 1/2	2 5/8	4 11/16	2 1/2	3 11/16	2 5/8	4 11/16
2 3/4	2 7/8	3 13/16	1 9/16	2 7/8	4 11/16	2 3/4	3 13/16	2 7/8	4 11/16	2 3/4	2 7/8	3 7/8	1 9/16	2 7/8	4 7/8	2 3/4	3 7/8	2 7/8	4 7/8
3	3	4 1/16	1 5/8	3	4 7/8	3	4 1/16	3	4 7/8	3	3	4 1/16	1 5/8	3	5 1/16	3	4 1/16	3	5 1/16
3 1/4	3 1/4	4 5/16	1 3/4	3 1/4	5 1/16	3 1/4	4 5/16	3 1/4	5 1/16	3 1/4	3 1/4	4 5/16	1 3/4	3 1/4	5 1/16	3 1/4	4 5/16	3 1/4	5 1/16
3 1/2	3 1/2	4 5/8	1 7/8	3 1/2	5 1/4	3 1/2	4 5/8	3 1/2	5 1/4	3 1/2	3 1/2	4 5/8	1 7/8	3 1/2	5 1/4	3 1/2	4 5/8	3 1/2	5 1/4
3 3/4	3 3/4	4 15/16	2	3 3/4	5 5/16	3 3/4	4 15/16	3 3/4	5 5/16	3 3/4	3 3/4	4 15/16	2	3 3/4	5 5/16	3 3/4	4 15/16	3 3/4	5 5/16
4	4	5 1/4	2 1/8	4	5 5/8	4	5 1/4	4	5 5/8	4	4	5 1/4	2 1/8	4	5 5/8	4	5 1/4	4	5 5/8
4 1/4	4 1/4	5 9/16	2 1/4	4 1/4	6	4 1/4	5 9/16	4 1/4	6	4 1/4	4 1/4	5 9/16	2 1/4	4 1/4	6	4 1/4	5 9/16	4 1/4	6
4 1/2	4 1/2	5 7/8	2 3/8	4 1/2	6 3/8	4 1/2	5 7/8	4 1/2	6 3/8	4 1/2	4 1/2	5 7/8	2 3/8	4 1/2	6 3/8	4 1/2	5 7/8	4 1/2	6 3/8
4 3/4	4 3/4	6 3/16	2 1/2	4 3/4	6 3/4	4 3/4	6 3/16	4 3/4	6 3/4	4 3/4	4 3/4	6 3/16	2 1/2	4 3/4	6 3/4	4 3/4	6 3/16	4 3/4	6 3/4
5	5	6 1/2	2 5/8	5	7 1/8	5	6 1/2	5	7 1/8	5	5	6 1/2	2 5/8	5	7 1/8	5	6 1/2	5	7 1/8
5 1/4	5 1/4	6 13/16	2 3/4	5 1/4	7 7/16	5 1/4	6 13/16	5 1/4	7 7/16	5 1/4	5 1/4	6 13/16	2 3/4	5 1/4	7 7/16	5 1/4	6 13/16	5 1/4	7 7/16
5 1/2	5 1/2	7 1/8	2 7/8	5 1/2	7 3/4	5 1/2	7 1/8	5 1/2	7 3/4	5 1/2	5 1/2	7 1/8	2 7/8	5 1/2	7 3/4	5 1/2	7 1/8	5 1/2	7 3/4
5 3/4	5 3/4	7 7/16	3	5 3/4	8 1/16	5 3/4	7 7/16	5 3/4	8 1/16	5 3/4	5 3/4	7 7/16	3	5 3/4	8 1/16	5 3/4	7 7/16	5 3/4	8 1/16
6	6	7 3/4	3 1/8	6	8 3/8	6	7 3/4	6	8 3/8	6	6	7 3/4	3 1/8	6	8 3/8	6	7 3/4	6	8 3/8

stock required for the rivet head. What are considered in some shops standard shapes and sizes for rivet heads are given in Table II.

Sizes of Rectangular Stock used in Making Square and Hexagon Nuts

In making nuts in center-feed hot-pressed nut machines of the types shown in Figs. 35 and 37, rectangular bar stock as shown in Fig. 39 is used, and a block of metal is cut off this bar, forced into the dies by the cutting-off punch, crowned, pierced and formed into a nut of the required shape. To allow

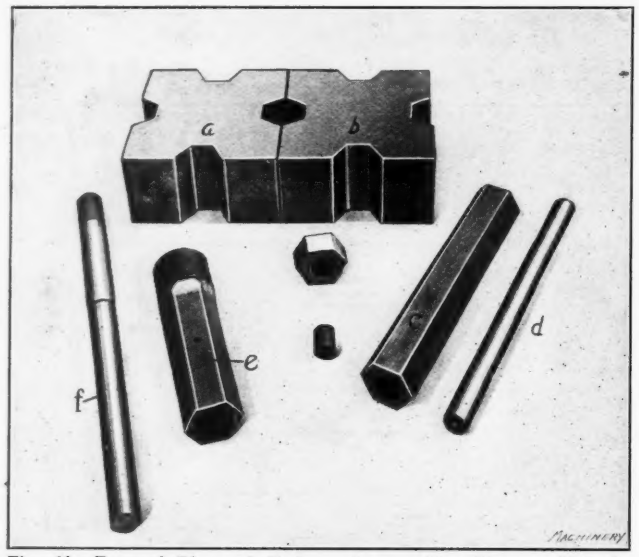


Fig. 44. Type of Dies and Tools used in making Hexagon Nuts in Center-feed Hot-pressed Nut Machine shown in Fig. 37

for upsetting the stock slightly and pressing it into the desired shape, a rectangular bar is used which is slightly thicker than the finished nut, and slightly less in width than the diameter of the nut across the flats. As explained in a previous paragraph, in order to produce a perfectly shaped nut it is necessary to waste a certain amount of stock as indicated at *a* and *b* in the illustration accompanying Table III. The amount of stock wasted depends upon the size of the nut and

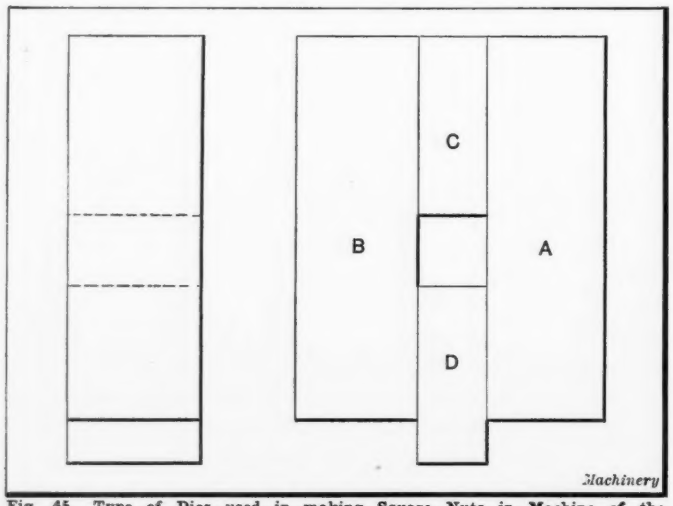


Fig. 45. Type of Dies used in making Square Nuts in Machine of the Type shown in Fig. 37

to a slight extent upon the temperature at which the bar is being worked.

In producing a hexagon nut only the front triangular corner is rounded (owing to the drawing over of the hot metal), whereas on a square nut, the entire front corner of the nut is rounded. A considerable saving of metal can be effected by turning the bar after each stroke of the machine, thus presenting opposite faces of the bar to the dies, as was previously explained. This can easily be done in making the smaller size of nuts where the bar does not exceed 40 to 80 pounds in weight. For large nuts, instead of turning the bar, a small amount of stock is wasted, as indicated at *a* and *b* in the illustration accompanying Table III, which varies from 1/16 to ¼ inch, depending on the size of the nut.

The hot-forged type of nut making machine shown in Fig. 41 has the advantage over the center-feed hot-pressed machine of not wasting any stock. The hot-forged nut machine, however, is only suitable for the manufacture of square nuts, and is only used where this type of nut is made in large quantities.

* * *

USEFUL SHOP MIXTURES

BY JOSEPH H. CHESTHAM*

Most engineers, draftsmen and machinists consider it a pleasure to collect various useful formulas, receipts and "shop secrets." The following are several which have been selected from the writer's own notebook as being worthy to be passed on. Among them, there are several that were obtained from two diemakers who are "old timers," having followed their trade in Germany and the United States for forty years or more. All are receipts which the writer has had a chance to see tried out, and they were considered either better or cheaper than the usual ones.

Drilling Composition.—Thirty gallons of water; 5 gallons of lard oil; 20 pounds of washing soda. Put the material in a lard oil barrel, invert a steam hose into the bung and boil thoroughly. Don't use a drop of mineral oil or a barrel that has contained it. This is a cheap mixture and will not rust the bright parts of the machine.

Oil for Screw Machine Cutting.—Two gallons of No. 520 paraffine oil; 1 gallon of lard oil. Mix the ingredients well. This oil is used instead of a cutting compound or lard oil.

Recovering Copper from Dipping Acids.—Some copper is dissolved when dipping brass castings in acid to clean them. In order to recover this copper, run the acid liquors from the washing tanks into a large wooden vat containing milk of lime, and stir thoroughly. The lime neutralizes the acids and precipitates the sulphuric acid as sulphate of calcium This acid is neutralized first, then the nitric acid is acted upon, and nitrate of calcium is produced. The clear liquid contains nitrate of calcium and nitrate of copper. Run this solution through any kind of scrap iron. The iron removes the copper from the solution, dissolving and taking the place of the copper. The copper settles at the bottom of the tank as a slush. At intervals, the copper may be taken out of the vat, dried and melted into ingots. All of the copper may be recovered if the supply of scrap iron is kept up.

Dipping Brass Castings to Clean Them.—Formula 1. Two parts nitric acid; 1 part sulphuric acid (vitriol).

Formula 2. For a bright dip: One part nitric acid; 1 part sulphuric acid.

Formula 3. For stripping nickel: Two parts nitric acid; 1 part sulphuric acid.

Dipping Solution to Preserve Iron Castings.—Mix 100 pounds dry lamp black to a paste with benzine. Then make a mixture of 5 gallons lamp black paste; 2 gallons turpine japan; 1 gallon boiled oil; 1 to 2 gallons cheap varnish. For very good work, add to the above 12½ pounds of refined lamp black ground in japan. Dilute the mixture with turpentine until it is as thin as water, and have the castings clean before dipping.

Mixture for Cementing Emery Cloth to a Lapping-Wheel.—4½ pounds of rosin; 3 pounds of paraffine; 9 ounces of vaseline. Melt the ingredients and mix them thoroughly. Heat the surface of the lapping wheel and spread on the mixture. Then rub the emery cloth down so as to excludc all air from between the surface of wheel and cloth. The surface of the lapping wheel should be clean before the cement is applied.

* * *

A new German invention for which very strong claims are being made makes use of a miniature transformer in each electric incandescent lamp and therefore has the advantage of allowing the use of a low-voltage metallic filament of, say, fourteen volts. These filaments are much stronger than those for a higher voltage. It is claimed that the new lamp is more economical in its use of current and from fifty to seventy per cent cheaper to make than the ordinary type. The small transformer is fitted in the socket, and the switch turns off the primary coil of the transformer so that there is no leakage current.

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MAKING THE HORTON-MORROW CHUCK

MANUFACTURING METHODS EMPLOYED IN PRODUCING A MODERN HAND-OPERATED DRILL CHUCK

BY CHESTER L. LUCAS*

Some interesting methods are employed in the manufacture of the Horton-Morrow drill chuck at the factory of the E. Horton & Son Co., Windsor Locks, Conn. The Horton-Morrow chuck is prominent among the hand-operated drill chucks, and a distinguishing feature is its quick-releasing device. By referring to the phantom illustration in Fig. 1 the construction and operation of the chuck may be readily understood.

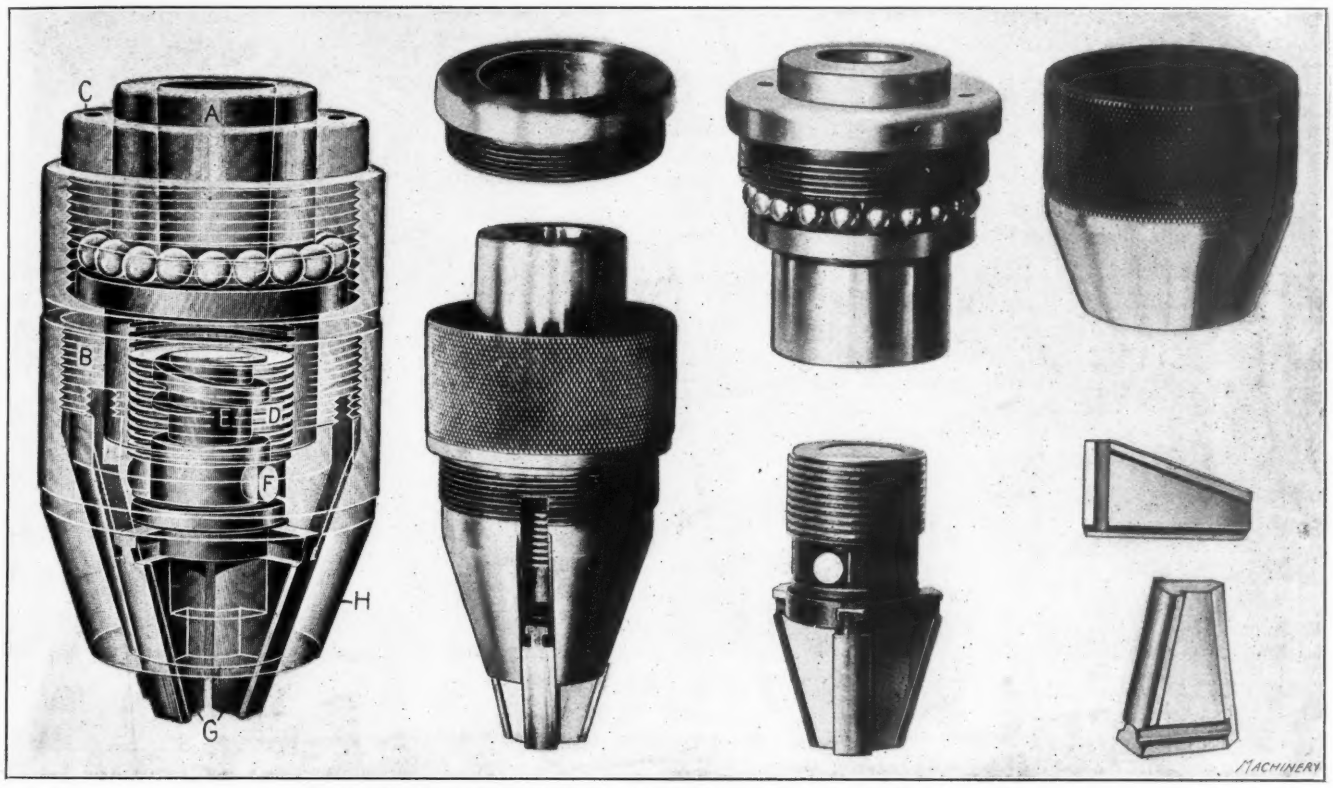

Fig. 1. Groupings of the Parts of a Horton-Morrow Chuck, illustrating Construction

In connection with the separate views of the parts shown beside this illustration, it will be seen that the chuck comprises a head *A*, which is fitted into the body *B* and held in place by a ring *C*, separated from the head by means of a row of ball bearings. The lower part of the head is fitted with a fine-pitch left-hand square-threaded screw into which is fitted the part *D*, known as the releaser. The active part of this releasing mechanism is the screw *E*, which is of coarse pitch and

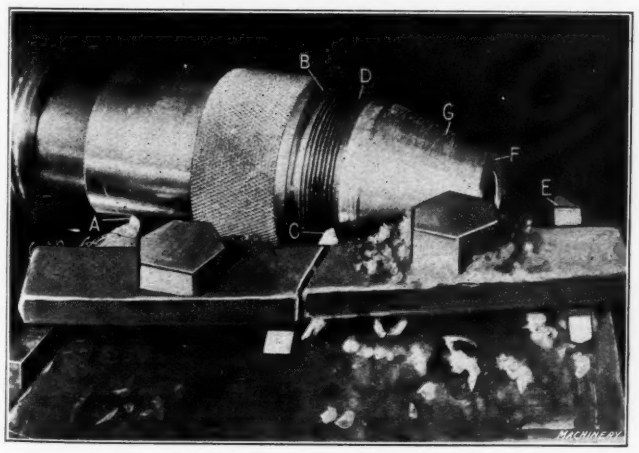

Fig. 2. Method of sizing Threading and turning Taper on the Body

operates in the releaser. The screw, however, is restricted to a small movement by the cross-pin *F*, operating in a slot which permits the screw to turn but a very few degrees in the releaser, the operation of which will be made apparent later. Into the bottom flange of the screw the three jaws *G* are

*Associate Editor of MACHINERY.

tongued. These slide in longitudinal slots provided in the body, and are confined radially by means of hood *H*. By observing these parts in detail in the separate illustrations and in place in the phantom view, it will be seen that when the hood and body are turned the releaser and jaws turn in the head *A* and the chuck jaws, through their contact with the inside taper of hood *H*, move up or down in accordance with the direction of the turning. One of the stumbling blocks encountered in designing a hand-operated drill chuck is that the drill in action tends to cause the jaws to grip harder, in proportion to the strain upon the drill. This, of course, is an advantage while the drill is in operation, but tends to make releasing very difficult. It is here that the releasing device of the Horton-Morrow chuck proves most effective. When releasing pressure is applied to the chuck, it operates first on

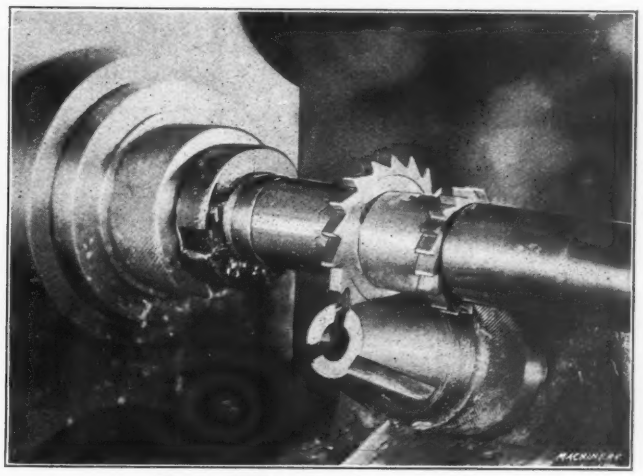

Fig. 3. Milling the Slots in the Body

the quick-pitch screw within the releaser, causing it to move the slight amount allowed by the cross-pin. While this distance is relatively small, the screw is of quick pitch, and the jaws are released just enough to bring them out of contact with the drill, and from this point on, the fine-pitch screw on the releaser actuates the jaws. Thus, we have all the advan-

tages of the fine-pitch screw for tightening and gripping the chuck jaws upon the drill, and yet the presence of the quick-pitch screw allows the drill to be released readily.

Manufacturing the Chuck

Having the construction and operation of the chuck in mind, it will be easier to understand the manufacturing operations which have to do with the different parts, and it seems most natural to treat each piece separately, as in this manner we can obtain a better idea of the way each part is prepared for the work it must perform.

The body shown beside the phantom view in Fig 1, as in all other cylindrical parts, is roughed out on the screw machine. As it leaves the screw machine, this part is 0.010 inch over size on all dimensions which require fitting. The rough body is first held in a three-jawed chuck, being gripped by the blank section which is later to be threaded—next to the knurled part. In this position the internal thread is chased and sized by a simple tapping operation. This being done, the body is held upon a threaded stud as shown in Fig. 2, and by means of the three-tool set-up the shoulder adjacent to the knurled screw is sized, the thread cut, the end of the chuck sized and the taper turned. Three stops are provided.

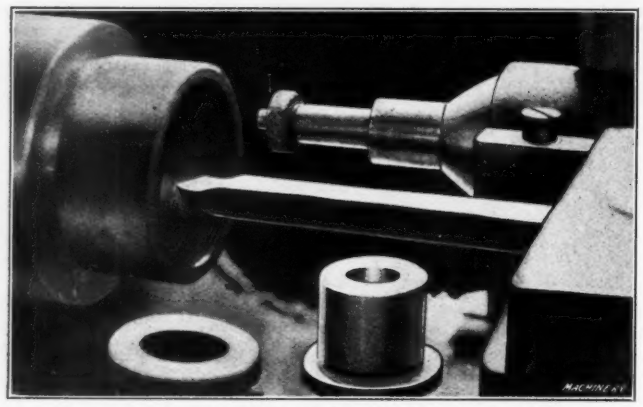

Fig. 4. Fitting the Head and Ring by boring and grinding

One of these serves to locate tool *A* in position to turn the side of the shoulder, as indicated at *B;* then changing over to a second stop, tool *C* is brought into the proper position to start the turning of the thread *D*. The lathe is, of course, kept in gear for the thread-cutting operation. Now by locating the carriage at a third stop, tool *E* is in position to finish off the end *F* and turn the taper *G*, the taper-turning being accomplished by a compound rest.

The next operation which is performed upon the body is that of milling the slots in which the jaws slide. These slots are spaced 120 degrees apart, and are milled with a wider slot at the top which forms a seat for the flanged edge of the jaw. The milling is done with the aid of two cutters mounted upon the arbor of the milling machine, the chuck body being screwed upon a stud on the milling machine table. Three wide cuts are first milled in the body, and then by setting over the

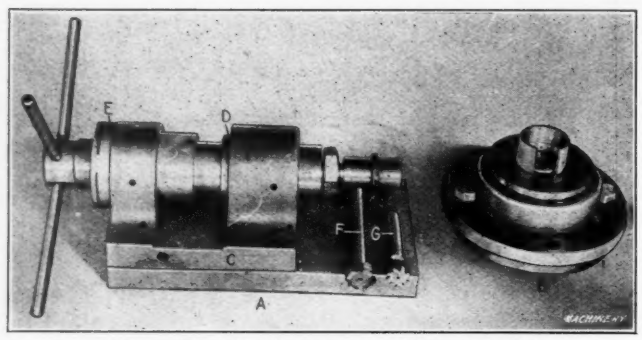

Fig. 5. Thread-milling Fixture and Draw-in Collet

milling machine table with the aid of the micrometer collar to the exact distance between the cutters, three narrow cuts are made in line with the three wide cuts. After this operation comes the fitting of the ring. The ring shown separately above the body, in Fig. 1, is another screw machine product, and the subsequent comparatively simple turning operations are performed with a gang-tool after the same manner that the turning of the body was done. As the lower face of the ring forms the upper member of the ball bearing, it is, of course, essential that it be hardened and ground. When it comes to the operation of fitting the ring to the body of the chuck it is in a hardened condition and ground on the shoulder which seats against the chuck body and also on the face against which the balls run.

Before the ring can be fitted to the body it is essential that the head shown with the ring and bearings in Fig. 1 be

Fig. 6. Boring and turning the Hood simultaneously

taken into consideration. This part is roughed out on the screw machine, and the first operation which follows is the milling of the left-hand internal square thread. This thread milling operation will be described in detail later. The taper in which the shank of the chuck is to be fitted is next reamed to size, and the piece is then capped at each end and casehardened, so that the internal taper and thread are left soft enough for subsequent fitting. After hardening, the sides of the flange and all of the external diameters are ground, for it

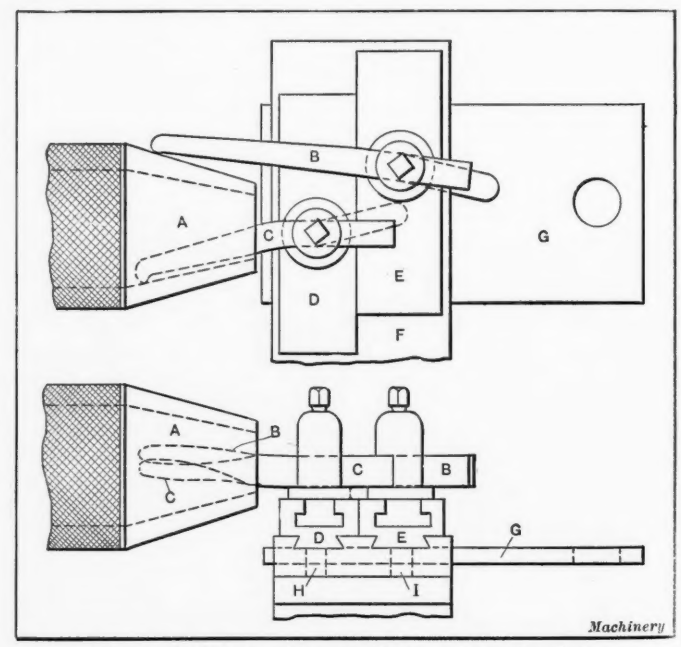

Fig. 7. Method of guiding the Boring and Turning Tools

will be remembered that the flange of the head forms the lower member of the ball bearing fixture.

Fitting the Ring and Head to the Body

For this operation, the body of the chuck is screwed into a bushing on the lathe spindle, and by means of a boring tool enough stock is removed from the inside surface to allow the head to slip freely into place. The ring is next screwed into the body, and by means of a grinding wheel located beside the boring tool, on the lathe carriage, the center of the ring is ground out until the upper part of the head will enter freely. This being done the only operation remaining is the facing off of the end of the body until the lower edge of the ring just comes in contact with the balls which run between the upper surface of the flange on the head and the ring.

The Operations on the Hood

The work performed on the hood of the Horton-Morrow chuck after it leaves the turret lathe is interesting. The hood which is shown at the upper right-hand corner of Fig. 1, is left from 0.005 to 0.010 inch oversize on all parts which must be fitted. The first work performed is that of chasing the internal threads, and for this part of the work the hood is held in the draw-in collet chuck illustrated at *B* in Fig. 5. In this view, the hood has been cut away to show just how it is held in the chuck and needs no explanation other than that the chuck is threaded to fit the lathe spindle and a draw bar runs through the lathe, being threaded to the taper plug shown in the hood. The threading is done in the ordinary way and the hoods next pass to a bench-worker where the threads are tapped out to size. From this point on, the hood may be held at the threaded section for performing succeeding operations. One of these operations is that of boring the internal taper and chamfering the outside as illustrated in Fig. 6. This operation is interesting, as the internal and external sections are both turned simultaneously with their proper tapers. To do this the boring tool and turning tool are held upon separate auxiliary slides, mounted upon the lathe cross-slide and by referring to Fig. 7, the operation of this arrangement may be followed. In this view the hood is shown at *A*, the turning tool at *B*, and the boring tool at *C*. Tools *B* and *C* are mounted on the cross-slide *F*, upon auxiliary slides *D* and *E*. A steel plate *G* is fitted under these auxiliary slides and studs *H* and *I* extend from the slides into inclined slots, shown in dotted lines in plate *G*. Plate *G* is held stationary, being bolted to the tailstock. From this construction it will be seen that when the lathe carriage is moved toward the work, the studs that reach into the inclined slots in *G* cause the auxiliary slides, and hence the tools, to traverse paths agreeing with the slots. As these slots are at the right angles for the taper of the bore and chamfer, it is only necessary to take successive cuts until the tapers are of the proper size. This size is determined by a taper plug gage. The strap loop encircling the lathe spindle is for the purpose of removing the hoods without injuring the knurled portion.

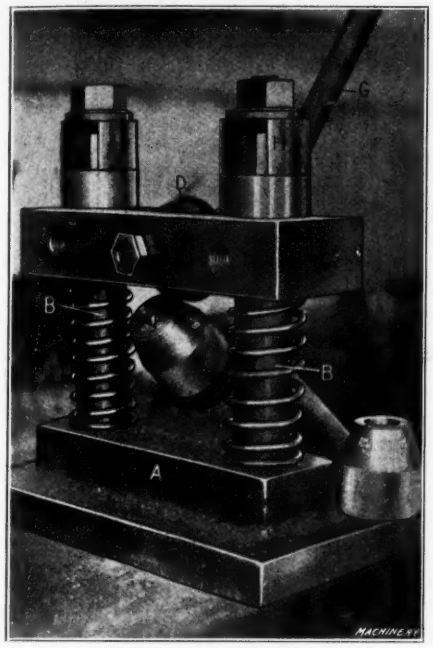

Fig. 8. Rolling the Horton-Morrow Name into the Hood

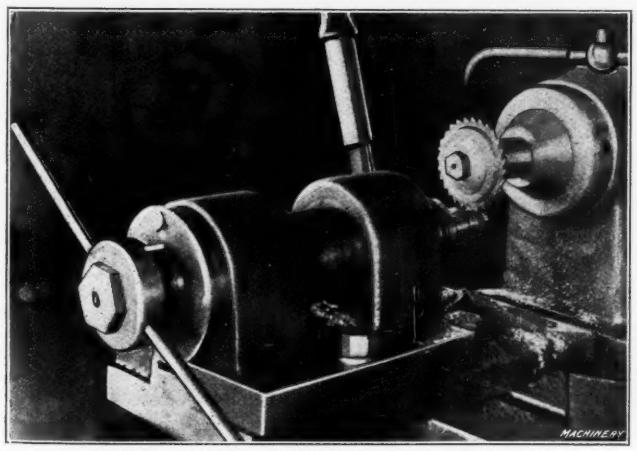

Fig. 9. Milling the Threads on the Releaser

After the turning operations have been completed, the name is rolled upon the hood in the stamping fixture shown in Fig. 8. This consists of a body *A* from which extend two heavy studs *B*. Sliding upon these studs is the saddle *C* which supports the stamping roll *D*. The hood *E* is slipped loosely over the arbor *F*, and, by means of handle *G* which is a lever from the stamp arbor, the stamp *D* is rolled over the hood thus impressing the letters upon its surface. For quickly removing the work from the fixture, slip-washers *H* are taken from the studs, allowing saddle *C* to be raised freely and the work removed. After hardening the hood, the internal taper is ground out, using a Heald internal grinding machine, to fit a taper plug gage.

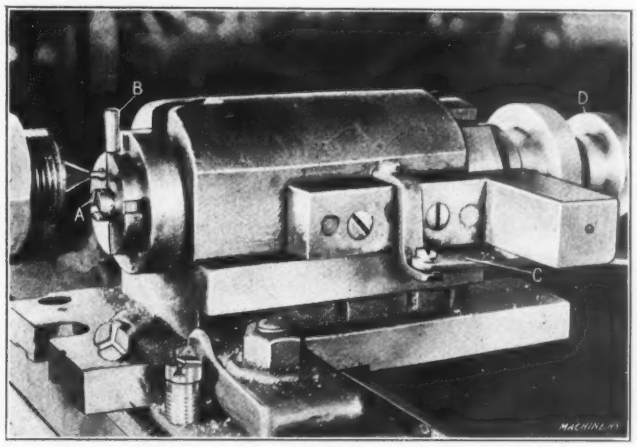

Fig. 10. Fixture used in T-slotting the Screw for the Jaws

Machining the Screw and Releaser

The screw and releaser shown in Fig. 1, with the jaws, form the basis of interesting thread milling operations, all of which are performed after the manner indicated in Fig. 9. The machine used is a small milling machine which has the thread milling cutter used for the square threads mounted upon the arbor. A fixture is mounted on the table of this machine for holding the work and turning it during the thread milling operation. This fixture is more clearly shown at *A*, Fig. 5, and consists of a main casting *C*, having a sleeve *D* in the front post and a threaded sleeve *E* in the rear post.

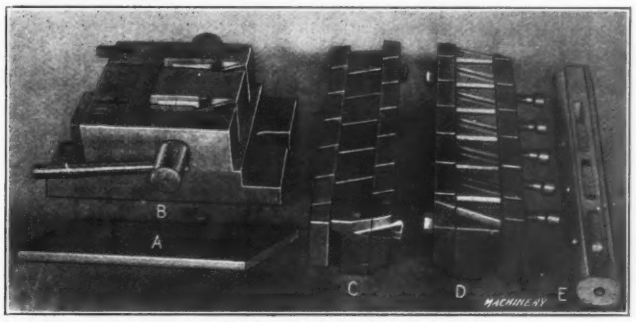

Fig. 11. Tools used in making the Jaws

Within this threaded sleeve a barrel which is threaded to fit the sleeve, works. This thread is of the same pitch as that which must be milled upon the work, and several barrels and corresponding sleeves with threads of different pitches may be used in the same fixture. The barrel is turned by means of hand levers radiating from the end of the barrel. The work is held upon the end of the spindle. In Fig. 9 one of the releasers is shown being milled while on the fixture shown separately in Fig. 5, a head is mounted, and is wrung onto a taper stud, so that the internal threads may be milled. When on internal work hobs are used as indicated at *F* and *G* in Fig. 5. Even though the work is turned by hand, it is surprising how smooth and accurate the resulting threads are. The coarse thread on the screw and the corresponding internal thread on the releaser are milled in the same manner, and in all there are two internal threads and two external threads to be milled on the chuck parts.

Referring to the separate illustration of the releaser, screw, and jaws shown in the lower part of Fig. 1, it will be seen that the jaws are held in place by being keyed into the flange of the screw. The milling of these T-slots is a delicate operation and is done with end-mills as shown in Fig. 10.

The screw indicated at *A* is held in an indexing fixture by means of pin *B*. A straight end-mill is held in the spindle of the milling machine and three radial slots are milled 180 degrees apart. The barrel of the fixture is indexed by releasing an indexing pin connected with lever *C* and turning the barrel by means of handwheel *D* until the next position is reached. A T-slotting cutter is next run through so as to

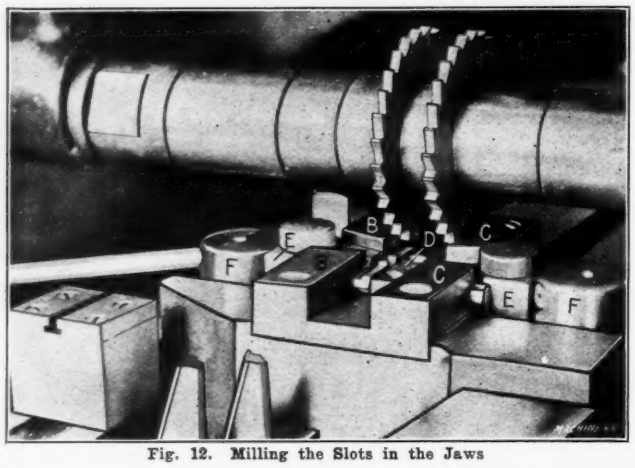

Fig. 12. Milling the Slots in the Jaws

widen the slots at the bottom and provide for the reception of the jaws.

Manufacturing the Jaws

The manufacturing operations connected with the jaws of the Horton-Morrow chuck comprise an interesting branch of the work for the reason that at the outset it was a difficult piece to produce economically, and for that reason considerable attention was paid to developing the process. Two views of the jaws may be seen in Fig. 1. The stock from which they are made is a high grade of carbon steel, and the first step consists in cutting the long bars to lengths of eight or ten inches, according to the size of jaw being made. One of these lengths of steel may be observed at *A* in Fig. 11, and it should be especially noticed that the ends of the bar are not at right angles to the sides, but are cut at an angle. The reason for this angular cutting will soon be apparent. The next operation performed upon the jaw-blanks is to mill them along one edge to give a working point from which the following operations can be located. Next a channel cutter which mills the stock from the central portion of the sides of the blank is run across each side, leaving the flanged

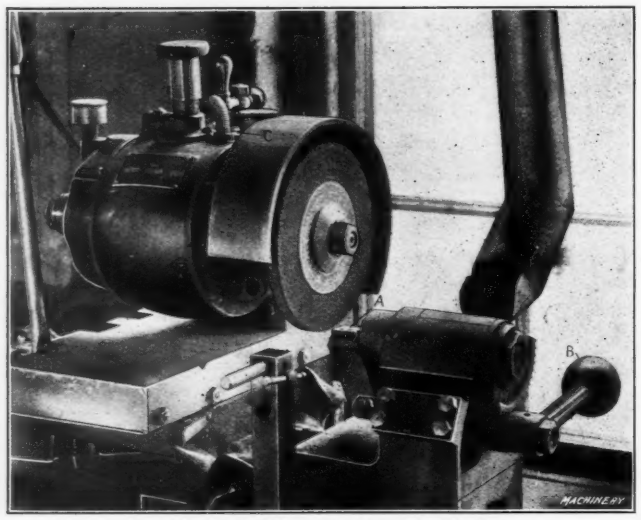

Fig. 14. Grinding the V-edges of the Jaws

edges which are to form the bearing sides of the jaws. A third milling operation follows which is to round the edges of the strip. After this point has been reached the strips are placed in an ordinary milling machine vise which is set up with the special jaws shown at *C* in Fig. 11. A pin at the end serves as a stop against which the lengths are located, and by swinging the milling machine vise at an angle with the gang-cutter which is used, five cuts are made through the steel, severing it into six rhombi. Each of these rhombi when split in the other direction form two jaw-blanks. The splitting operation is accomplished by means of the special jaws *D*, which fit in the milling machine vise. Set-screws at the side serve to take up the slight differences in length between the blocks, and a gang of six cutters separates the blocks into twelve jaw-blanks.

It is next necessary to mill the angles on the gripping edges of the jaws and for this operation they are held in the fixture shown at *B* in Fig. 11, which accommodates two jaws, and by means of a pair of angular cutters the V-shaped edges are given to the jaws. The fixture is recessed so that the jaws slip down almost flush with the top surface and the clamping levers at the sides bind the blanks in place for the milling. A second milling operation follows which consists in tonguing the ends of the jaws to fit the T-slots in the screw which were shown being milled in Fig. 10. This is a simple milling operation making cuts in four jaws at once. The fixture and the operation are shown in Fig. 12, and the jaws are held by being placed two at a time, back

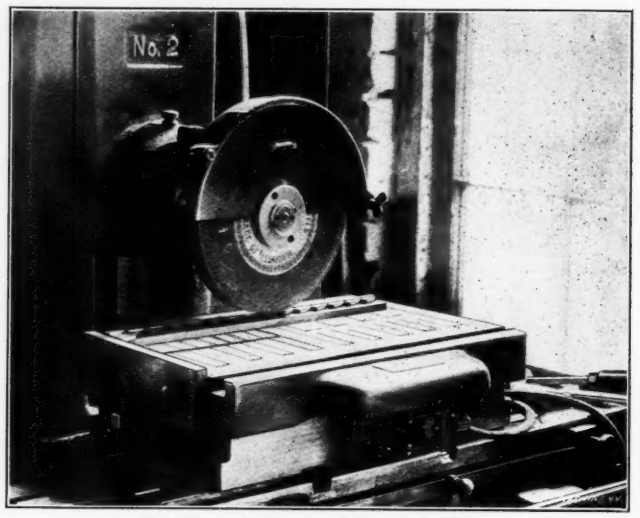

Fig. 13. Grinding the Sides of the Jaws

to back, in the slots formed by blocks *B* and *C*. The tops of the jaws bear against the center stop *D*. Filler blocks *E* which are wedge-shaped are placed between each two jaws and simple clamping cams *F* are brought to bear against the ends of these blocks, thus holding the four jaws firmly in place against the center stop. The fixture is extremely simple in its operation and holds the jaws positively in place.

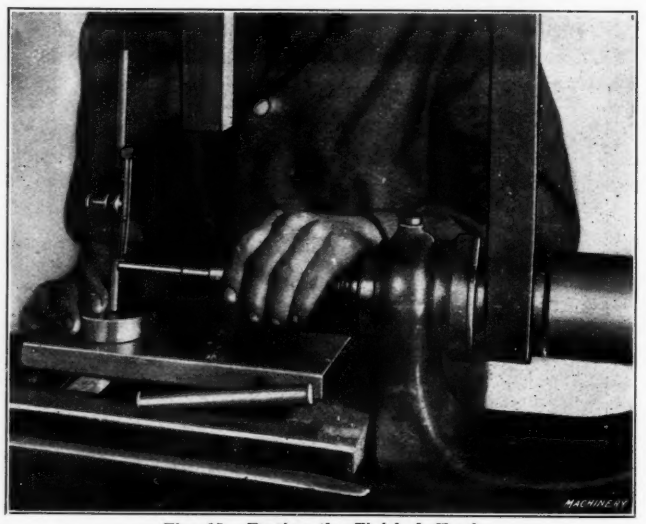

Fig. 15. Testing the Finished Chuck

At this point the jaws are hardened, and the following operations are those of grinding the sides, the gripping edges, and the radii on the bearing edges. For grinding the sides a small surface grinder is used and a number of the blanks are supported on a strip having clearance for the tongued edges of the jaws. This strip is in turn mounted upon a magnetic chuck and in this position the sides of the jaws are ground, as shown in Fig. 13.

The machine for grinding the gripping edges of the jaws is very interesting and in Fig. 14 it may be seen that it

consists of a motor-driven grinding wheel mounted upon a sliding head, which can also be rapidly reciprocated in a lateral direction. The jaw, indicated at *A*, is held in the chuck at the opposite end of the machine. This fixture holds the jaw so that it may be swung to either of two positions, to agree with the two faces which must be ground. The swinging is done by means of a hand-lever *B* which may be seen at the right-hand end of this illustration. After the jaw has been firmly gripped in the machine the grinding wheel is moved by hand with a combined lateral and longitudinal motion over the side of the edges of the jaw being finished. The wheel is then drawn back, the jaw swung to the opposite position and the other side of the jaw finished. By means of a micrometer adjustment shown at *C* the depth of the grinding may be accurately controlled. In making the Horton-Morrow chuck no grinding is done upon the jaws after they have been fitted to the chuck. The jaws are absolutely interchangeable, and no fitting is required when assembling.

The edges of the chuck jaws which bear against the inside surface of the hood must be finished at a radius slightly smaller than that of the side surface of the hood. This is done by holding the jaws in the special arbor illustrated at *E* in Fig. 11. This arbor is slotted so that six jaws may be held in position with set-screws, there being three jaws on each side of the arbor. From this point the grinding operation is a simple one, being merely a question of finishing them to size.

Assembling and Testing the Chuck

The manufacturing operations on the parts of the chuck are performed as accurately as possible, so that the assembling department will have as little as possible to do in fitting the parts of the chuck, only such operations as cleaning out the threads after hardening and reaming out the taper for the spindle and a few minor operations are necessary in putting the chuck together.

The testing of the assembled chuck is shown in Fig. 15; this is particularly rigorous, every chuck being tested with ground spindles in conjunction with an indicator, the requirements being that they run within a maximum variation of 0.002 inch.

* * *

BROACHING VS. MILLING

BY FRANK J. LAPOINTE*

The field of usefulness of the broaching machine has been greatly broadened during the past few years, and machines of this type are now being used for many classes of work that were formerly finished by milling. The following gives a description of an operation which was recently handled on a J. N. Lapointe broaching machine in place of a milling machine. Fig. 1 shows an end view of the piece to be broached; Fig. 2 shows the work in place on the machine ready for the broaching operation; and Fig. 3 illustrates the type of broach which was used for this operation. By referring to Fig. 1 it will be seen that there are four surfaces to be finished on each side of the work. The material is drawn steel and there was about 1/32 inch of metal to be removed from each face. These pieces were formerly milled, and by this method about five or six pieces were finished per hour, the accuracy of the work being so unreliable that the pieces were not considered interchangeable. The present method is to employ twin broaches—one on each side of the work—the two broaches operating at the same time. By this method the pieces are held within a very close limit and can be relied upon to be interchangeable. Adjustments are provided on the fixture for regulating the depth of cut so that any wear which may develop can be readily compensated for. Two pieces of work are placed in the machine at once and from one to one and one half minute is required to pull the broaches through. This gives a production of from 80 to 100 pieces per hour.

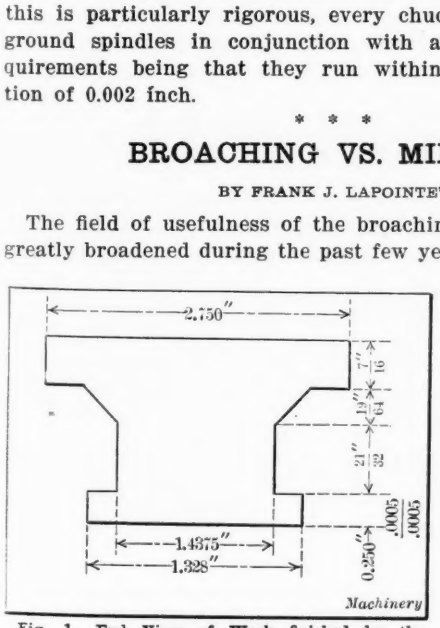

Fig. 1. End View of Work finished by the Broaching Operation

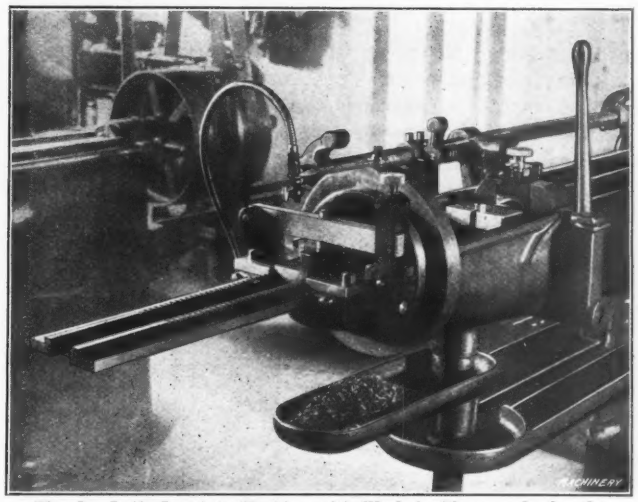

Fig. 2. J. N. Lapointe Machine with Work in Place ready for the Broaching Operation

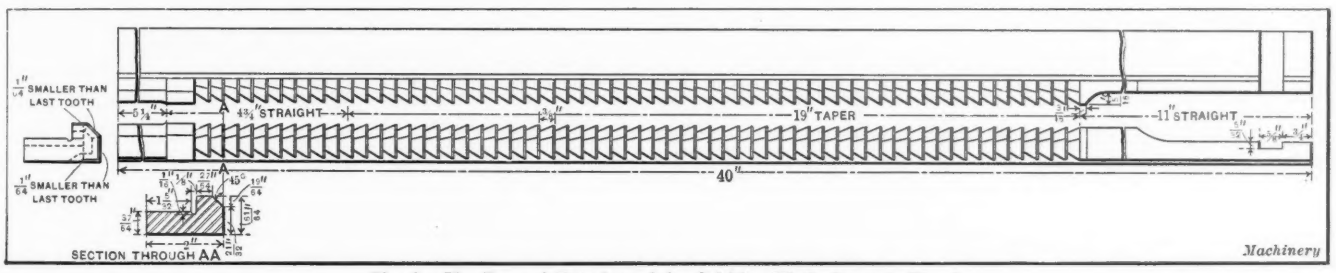

Fig. 3. The Type of Broach used for finishing Work shown in Fig. 1

Comparing the accuracy and production obtained through finishing these pieces by broaching with that obtained by milling, it will be seen that the broaching machine effected a considerable economy on this work. The broaches were made of high-speed steel, ground all over and operated at a cutting speed of six feet per minute. The No. 3 J. N. Lapointe broaching machine was used and the finish produced on the work was entirely satisfactory. The fixture for holding the work is made so that the work can be released by merely turning a knurled knob, and removing the finished work and replacing it with fresh blanks takes only a few minutes of an operator's time.

* * *

The American Museum of Safety has appointed a committee to award annually the medals given by Mrs. E. H. Harriman to the railroad which shall have done most to promote the "safety first" idea. Three medals will be awarded each year. A gold medal will be given to the railroad company itself, a silver medal to the official of the operating department of that road who has done most to promote safety on his road, and a bronze medal to the employe of the winning road who has been most conspicuous in the promotion of safety. It is planned to give with each medal an engraved certificate which will bear the name of the giver and that of the recipient. The first medals will be awarded in January, 1914.

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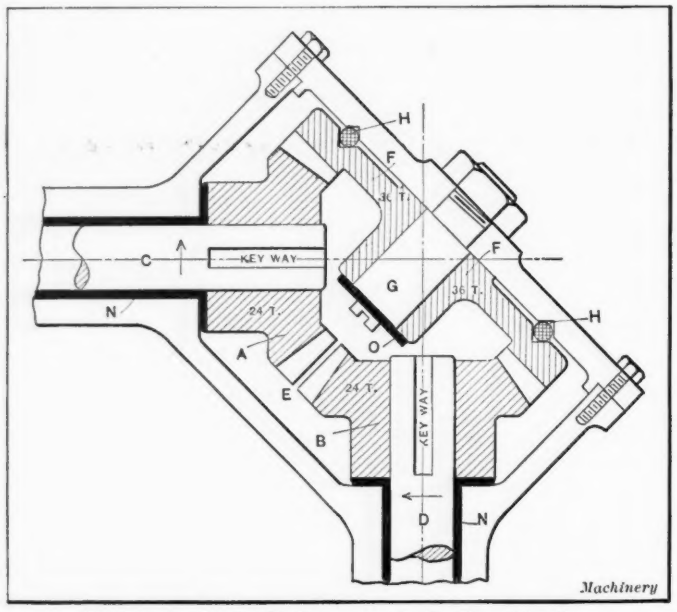
LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY.

BEVEL-GEAR DRIVE FOR SHAFTS RUNNING IN THE SAME DIRECTION

The miter or bevel-gear drive is one common means of driving shafts at angles. The ordinary miter, bevel or angle gear wheels rotate shafts in opposite directions, but sometimes it is desirable to rotate the shafts in the same direction. The accompanying illustration shows a means of securing this result by the use of three angle gears.



Bevel-gear Drive for Shafts running in the Same Direction

A and *B* are a pair of 24-tooth wheels mounted on the shafts *C* and *D* which do not mesh at *E* but are connected by the larger angle gear *F* having 36 teeth; this gear is supported by the stud *G* mounted in the plate which is bolted to the gear-case. Bushings *N* are provided in the frame, which can be removed and replaced when the bearings are worn, thus bringing the shafts back to their original alignment. If a closed gear-case is provided, it may be made to hold a supply of lubricant.

The balls *H* back up the gear *F* on stud *G* and take the thrust. It is evident that if shaft *C* and gear *A* rotate as indicated by the arrow, then by means of gear *F*, meshing with *A* and *B*, gear *B* and shaft *D* will rotate in the same direction as *A* and *C*.

This arrangement will be found to be a good substitute for the ordinary quarter-turn belt drive. A valuable feature is the possibility of locating one horizontal shaft above or below another. Thus the advantage of a skew bevel gear can be obtained by means of this combination. This drive when made and put up right, especially when mounted in a case containing a quantity of lubricant, will last for years in hard service with very little care.

Springfield, Mass. FRANCIS W. CLOUGH

AN ECCENTRIC TURNING FIXTURE

The turning fixture here illustrated was designed for the production of screws or small studs which are made with some portion eccentric to the remainder of the piece. Its use insures a very accurate throw of the eccentric, and the fixture is made adjustable through a wide range, thus accommodating a great variety of work.

The fixture consists of a body *A* which has a taper shank turned to fit the head center of the lathe, a collet holder *B*, accurately ground, and the eccentric indicating device *C*. *A* has a planed vee on the flange to which the collet holder *B* is fitted with a gib and to which it may be firmly clamped by means of two locking bolts, which are tapped into the body *A*, but which have elongated holes in *B*. The indicating device is interesting because of its simplicity. It consists of a five-sided plate, made so that the distances of its sides from the center are respectively, 0, 1/64, 1/32, 1/16, and ⅛ inch. This indicator is so fastened to the flange *A* that when the zero side of the plate is in contact with the side of slide *B*,

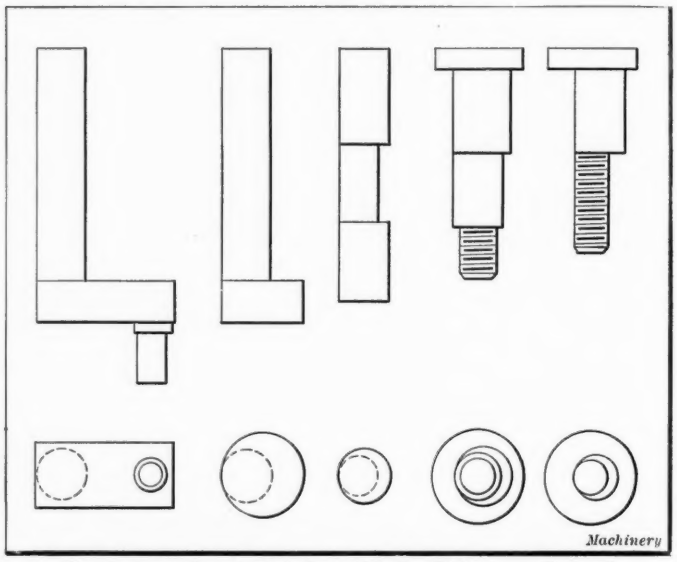


Fig. 2. Examples of Work for which the Fixture was designed

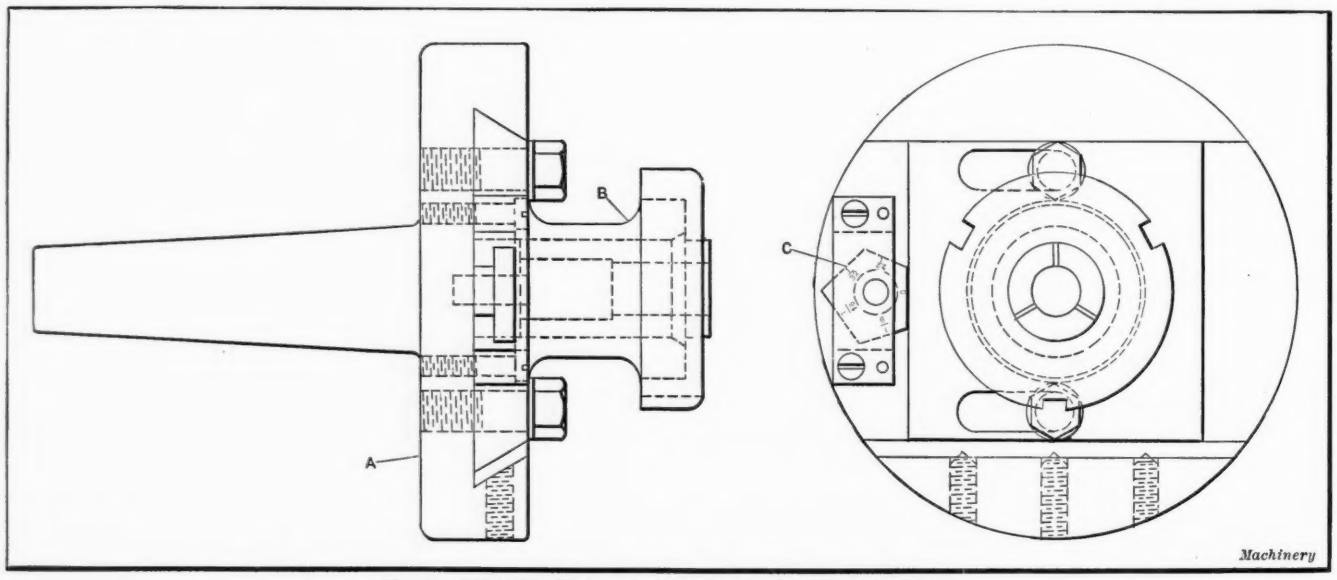


Fig. 1. Adjustable Fixture designed for turning Eccentric Pieces

the collet holder is central with the spindle, and as the various sides are placed in contact with *B*, the collet holder is set off center the amount marked on that side. For any throw that cannot be obtained from the plate, a standard set block may be inserted between the zero side and the side of the collet holder *B*, thus giving the required result.

It may be of interest to mention the way in which this fixture was made. The blank *A*, including the taper shank, was turned on the lathe, after which the V-slide was milled on the milling machine. Then the collet holder *B* was milled and fitted to *A*, and clamped in the zero position. The assembled fixture was then replaced in the lathe, and the hole for the collet or spring chucks was bored out, after which it was taken apart and *B* was hardened. The collet holder was then replaced and *B* ground to fit the spring chuck. The spring chucks are of standard make, and a set of them is used in connection with the fixture. The use of this fixture eliminates the slow method of measuring the eccentricity of a piece by means of an indicator or height gage, and it can be quickly changed from one setting to another. Duplicate work can be easily and quickly handled. A few of the pieces produced by this fixture, shown in Fig. 2, indicate the wide range of work which can be accommodated.

Beverly, Mass. EVERETT CHIPMAN

BUSHING A PROPELLER TAIL-SHAFT

The writer takes this opportunity of presenting the following reply to the inquiry of S. H. S. in the December issue of MACHINERY in regard to the proper method of bushing a propeller tail-shaft. A very satisfactory method of handling steel shafts is to cast a brass sleeve around them. An even better method, however, is that of shrinking on a brass sleeve and when this is properly done, the bushing should wear down to a quarter of an inch in thickness and still give satisfactory results. The objection to the use of this method is that it requires more time than is usually given to a job of this kind—especially in small shops—and a full day is not too much time to devote to boring and shrinking on the sleeve. A sleeve 2½ inches in diameter should not be over 12 inches in length and can be accurately bored on a lathe. Large sleeves of the type used on tug boats, where the length is from two to three feet, may be conveniently handled on a horizontal boring mill, although the bore will usually show a slight taper due to the springing of the bar or to inaccuracy of the fit of the yoke bushing. All of the work should be calipered and a parallel shaft used with a parallel sleeve; but if the sleeve shows a taper, a corresponding taper should be cut on the shaft. A shrinkage allowance of 0.001 inch per inch of diameter should be made. For a shaft 2½ inches in diameter, 0.003 inch shrinkage allowance will give excellent results. Hard brass should be used to resist the shrinkage strains and an alloy of 25 parts of copper, 2 parts of zinc and 4.5 parts of tin will meet average requirements. After shrinking the sleeve on the shaft, it should be pinned in position with brass studs screwed in as hard as possible. These studs are then headed over and smoothed off, after which the entire piece is finished.

C. R. C.

BORING A LARGE COMPRESSION COUPLING

At the plant where the writer is employed, there were a number of cast steel compression couplings to be machined. The principal difficulty met was in boring them, on account of their large size. The dimensions of one of the couplings are shown in Fig. 1. As there was no horizontal boring machine in the shops at that time, the use of a 36-inch lathe had to be resorted to. It will be noticed that the length of the work would not permit an ordinary boring-bar to be used, because it would not be rigid enough. Consequently, it was decided to make an attachment for the lathe that had the required rigidity, as the number of couplings to be bored was sufficient to warrant the expense involved.

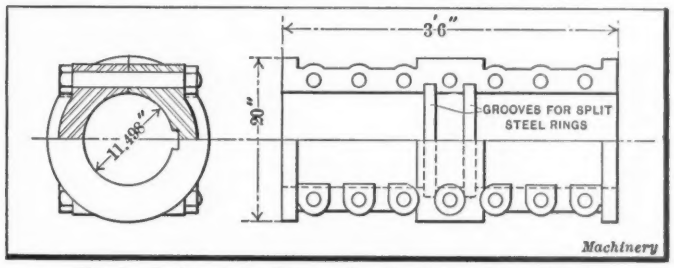


Fig. 1. Design of the Compression Coupling to be machined

Referring to Fig. 2, where the general arrangement of the attachment is shown, the method of procedure was as follows: Before starting to bore a coupling, a piece of rough iron was driven into one end, after which the coupling was hoisted to the lathe chuck, with the end toward the tail center that had the rough iron block driven into it. A center was drilled in this block and used to help steady the coupling while turning the end to receive the steadyrest *H*, as shown in Fig. 2. The tailstock and iron block were then removed and the bar, boring head, rests, etc., were set up on the lathe, after which the boring operation was started. The boring head *A* was fed along the steel bar *B* by means of a smaller steel bar *C*, which is fastened in a block *D* set in the compound rest of the lathe carriage. The steel bar *C* was fastened to the boring head by means of the two tap bolts *E*. The boring head carries two "Novo" tools which were held in place by set-screws. The steel bar *B* was supported at the forward end by a brass-lined steady bearing, and at the rear end by a support containing a set-screw to keep the bar from turning.

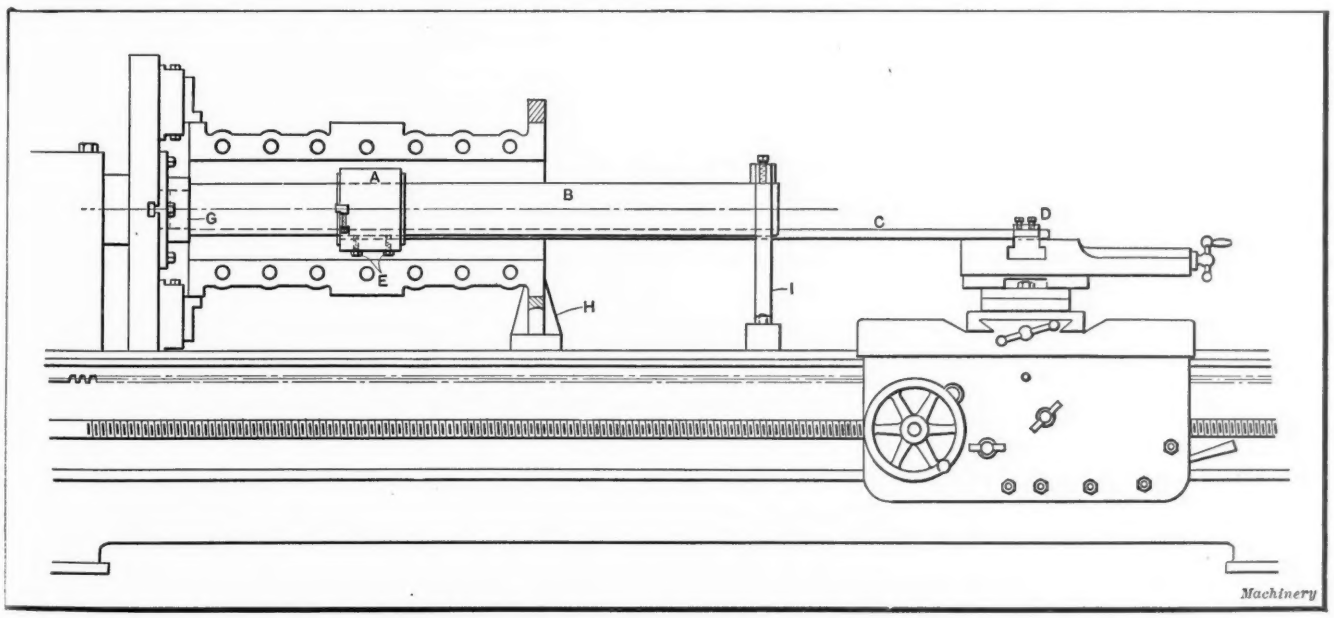


Fig. 2. Fixture used for boring Couplings on a 36-inch Lathe

The details of the various parts are shown in Fig. 3. The step bearing *G* was bolted to the faceplate of the lathe before the brass lining was bored out and was not removed until all the couplings were bored. The steadyrest *H* and bar support *I* were also bored out on the same lathe. The steel ring *J* has a beveled surface on the inside of the ring, so that when it

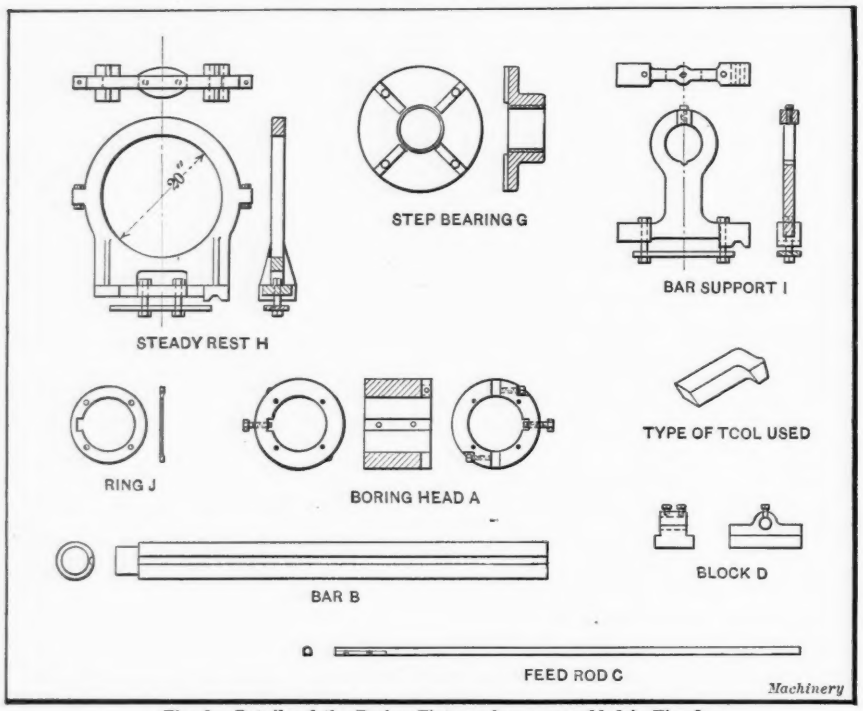


Fig. 3. Details of the Boring Fixture shown assembled in Fig. 2

was fastened to the boring head, there was space left for packing, which kept the dust and fine chips from getting under the head.

In conclusion, it may be stated that the grooves shown for the split steel rings in Fig. 1 were not cut in the lathe, but instead, the work was taken to a vertical boring mill for this operation, as well as to machine the unfinished end of the coupling. Considering conditions, and the nature of the couplings, a good average time was made in machining them.

A. H. MYERS

York, Pa.

BLANKING, FORMING AND PUNCHING DIE

The following is a description of a set of tools used for producing a brass cap of the form shown in detail in the illustration, between the punch and die. This cap is made of No. 22 gage sheet brass. A number of articles have been published in MACHINERY describing tools used for this kind of work, but the punch and die shown possess a number of interesting features. They were designed for use on a single-action press with an inclinable bed, and all parts were made interchangeable with the view of reducing the cost of repairs to a minimum.

Referring to the illustration, the punch-holder *A* is made of hardened tool steel and the lower end constitutes the blanking punch and forming die for drawing up the flange of the cap. A reamed hole *R* is provided in the punch-holder to receive the center-hole punch *G* which is a press fit in the holder. A ¼-inch hole is drilled through the center of the shank to provide for knocking out the punch *G* when it is necessary to dismantle the punch and die for making repairs. The piercing punch retainer *E* is also made of tool steel and clamped to the punch-holder *A* by means of three small screws. Three slots *S* are cut in the punch-retainer *E* to enable it to clear the heads of the knock-out pins *C* which are made of cold-rolled steel. These knock-out pins are a press fit in the stripper *D* and slide up and down in the slots *T* which are cut in the punch-holder *A* for that purpose. The "kicker" *F* strips the work off the piercing punches *P* and the punch *G*. This kicker is operated by the pins *C*, the heads of which engage with its upper surface in the manner shown in the illustration. It will be seen that an off-set is provided at the top of this kicker to prevent it from falling out of the punch. The piercing punches *P* are made of hardened drill rod and are upset at the upper end to prevent them from dropping out of the holder; they are a sliding fit in the kicker *F*. The compression spring *B* operates the stripper *D*, which, in turn, operates the kicker *F*.

The method of assembling the punch is as follows: The spring *B* and stripper *D* are put in place around the punch-holder *A*, after which the pins *C* are inserted from the inside. Next, the retainer *E* is placed in the punch-holder and the three screws which are provided to keep it in place are tightened. Then the kicker *F* is inserted and the center hole punch *G* pressed into position.

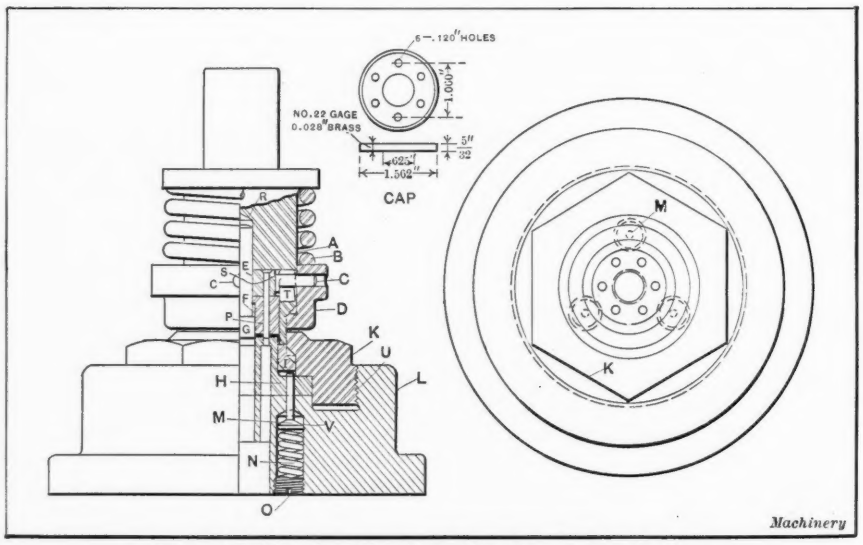
The die consists of a holder *L* which is a steel casting. The die-holder carries the blanking die *K* which is made of hardened tool steel and screwed into the die-holder at *U*. A clearance of ⅛ inch is allowed below the die *K* to provide for having it clamp the piercing die *H* in place in the die-holder. Two dowel pins, not shown, keep the die *H* from turning. A kicker *I*, which rests on three spring pins *M*, is made of machine steel and left soft; this kicker strips the work from the die *H*. Three holes are drilled through the die-holder from the under side to receive the springs *N* and pins *M* which operate the kicker *I*. Threaded plugs *O* are provided at the lower end of these holes and by adjusting their position, any required tension may be obtained in the springs *N*.

All of the hardened parts of the punch and die are ground to the required limit. The sheet brass used for the caps should be oiled in order to relieve the working parts of the tool. A trained operator running a press equipped with a punch and die of this type is able to produce from 18,000 to 20,000 caps in a ten-hour working day.

Buffalo, N. Y. J. STANITZ

SECTION DRAWINGS

In the April issue of MACHINERY, Mr. E. W. Tate refers to the method of indicating cast-iron sections which I described in the February number. Evidently, the method was not fully understood. It was not the intention to suggest this method for use on *all* classes of work, although it is capable of general application. The main use of tinting ink is on



Die for blanking, forming and punching Caps at One Operation

all large full-sized sections, such as the beds of machines. In cases where time and money is of no consequence, the tinting ink method should not be used. Cross-hatching is not essential to the production of a good looking drawing, however, even where the drawing is used to sell a machine.

The tinting ink is not applied *all over* the cross-section, as the cloth would be rendered unfit for use by the shrinkage that would result from such a procedure. A border of ink, about ¾-inch in width, is painted around the outline of the section. The ink is easily applied, and the appearance of the blueprint produced from such a tracing is very satisfactory. It does not need an "artist" to apply it, as any "cub" can follow a line with a brush. One of the men in the drafting-room mentioned, not only uses the ink to show the sections, but shades all of his work with it. His drawings have always been used as a selling feature, and this shading certainly produces a very pleasing effect.

New Britain, Conn. J. M. HENRY

BULLDOZER ATTACHMENT FOR BENDING AND PUNCHING FRICTION PLATES

The accompanying illustrations show a coupler friction plate used on freight cars and a bulldozer attachment designed by the writer for bending the plate and punching the holes in it; this attachment is in use at the B. & M. R. R. Shops, Concord, N. H. Both the bending and punching operations are performed at one stroke of the machine. These coupler friction plates are made from iron or steel stock ⅜ inch thick and have four 11/16-inch holes *A* as shown in Fig. 1. In the illustration of the attachment shown in Fig. 2, *A* is the punch-holder to be bolted to the bed of the machine, *B* the stripper and *C* the die to be attached to the ram. These parts were made from cast iron and the only machine work done on them was to plane the bottom of the punch-holder *A* and the back of the die *C*, except, of course, to drill and tap the holes that were required. The stripper *B* is operated by a spring *D* which is an old car spring picked from the scrap pile.

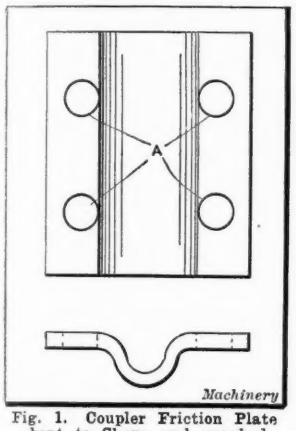


Fig. 1. Coupler Friction Plate bent to Shape and punched

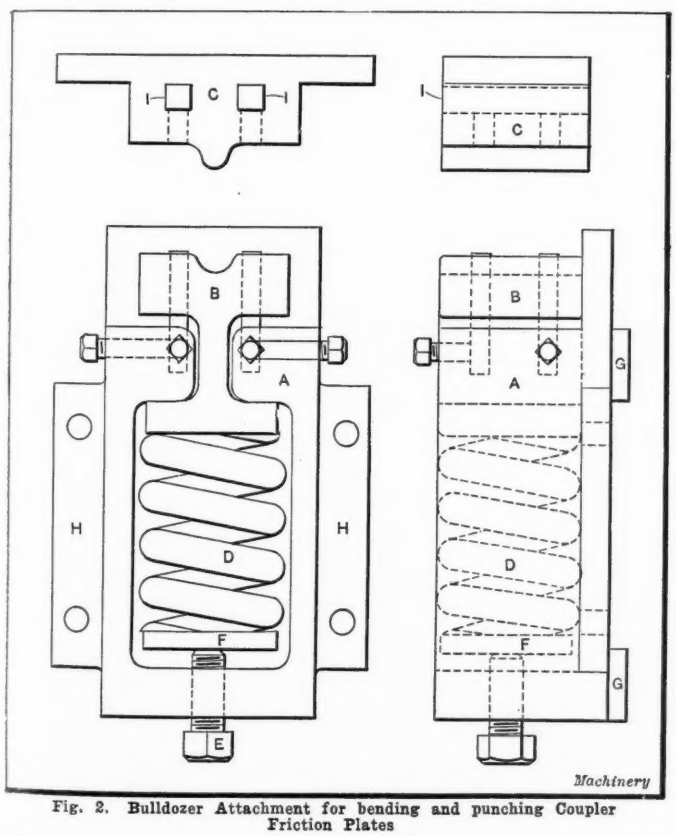


Fig. 2. Bulldozer Attachment for bending and punching Coupler Friction Plates

The tool operates as follows: A piece of stock, after having been cut to size and given the proper heat, is placed on edge in front of the stripper *B*. The die *C* then advances and forces the stock against the stripper *B* which bends it to shape and then forces it on to the punches as *B* moves back against the spring. The tension of the spring *D* should be strong enough to have the plate bent nearly to shape before the punching operation begins, and to strip the finished piece from the punches when the ram moves back to its idle stroke. The required tension of the spring can be regulated by means of the adjusting screw *E* acting against the block *F*.

It will greatly assist the operator in lining up the punch and die to unscrew *E* and remove the block *F*; this will allow the stripper *B* to slide back against the punch-holder *A*. In this position, the punches will extend through *B* for a sufficient distance to show if they are in line with the die. After the punch-holder *A* and die *C* are bolted in position, the block *F* is replaced and screw *E* adjusted. Two lugs *G* are cast on the bottom of the punch-holder *A* to fit into slots in the table of the machine. The projections *H* provide for bolting the punch-holder *A* in place. Stripper *B* acts as a support for the punches, and the holes through which the punches pass should not be more than 1/32 inch larger than the diameter of the punches, but they must be large enough so that the punches will not bind against the stripper. When iron stock is used, one set of punches will punch from 5000 to 10,000 holes if they are not allowed to become too hot. When the machine is running very fast, water should be used to keep the punches cool. The punches can be cut from 11/16-inch drill rod and the punchings drop out through the hole *I* in the die.

Concord, N. H. NED D. MARTIN

MICROMETER HEIGHT GAGE

In designing the gage shown in Fig. 1, it was the object of the writer to devise a means of using a 1½- and 2-inch B. & S. inside micrometer for a height gage. This did not injure the tool in any way or detract from its usefulness as an inside "mike." It will be seen that a fixture is made to support the micrometer. The base of this fixture is made of machine steel, casehardened, ground and lapped on the bottom. The bar and bracket of the fixture are of tool steel.

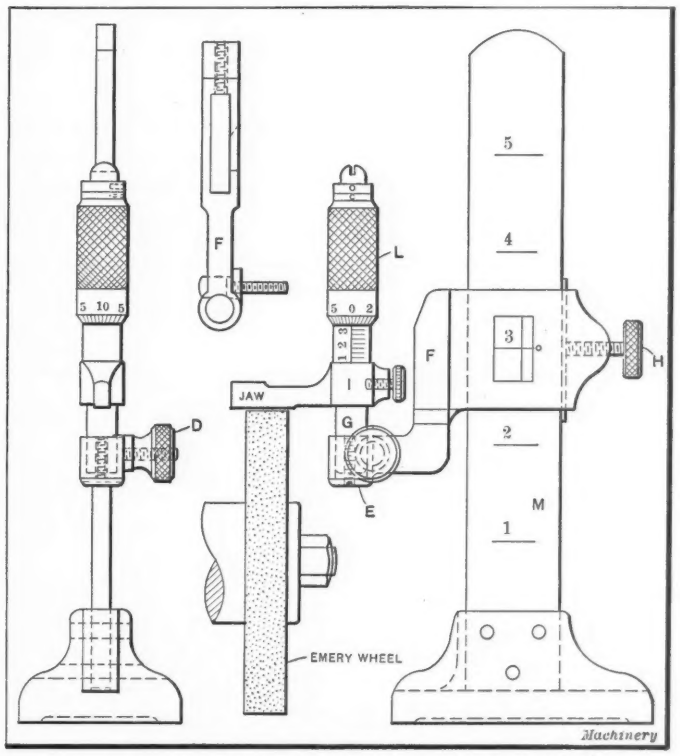


Fig. 1. Micrometer Height Gage made from B. & S. Inside Micrometer

Referring to Fig. 2, the scriber *A* is of hardened tool steel, and the two edges marked *a* are ground and lapped so that they are perfectly parallel with each other. The clamp *B* is a regular Brown & Sharpe height-gage clamp which can be purchased through the hardware dealers. The adapter block

C, which goes over the top of the jaw, is of tool steel and is for the clamp screw to bear against.

The bar *M* in Fig. 1 is graduated in inches or, if a metric "mike" is used, to twenty-five millimeters. The following method is used: After assembling the bar and base, the base is clamped lightly on an accurate surface plate and the divisions are then scribed from accurate size blocks or from a standard height gage. The lower jaw, thimble and screw are then removed from the micrometer, leaving the head jaw as

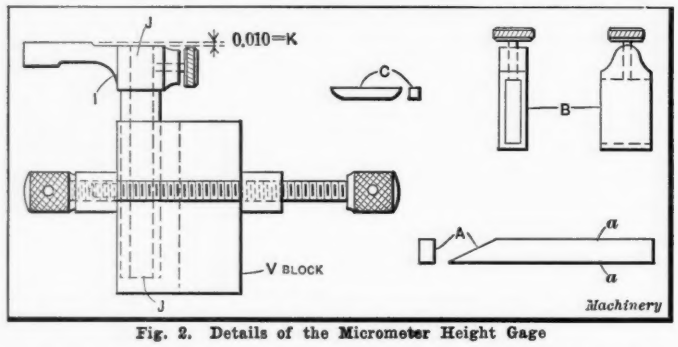


Fig. 2. Details of the Micrometer Height Gage

at *I;* the hole *J* is plugged at both ends with a small cork to keep emery from falling on the threads. The head jaw *I* is next clamped lightly in a V-block and the clearance *K* is ground 0.010 inch below the jaw, a magnetic chuck grinder being used for this purpose. After demagnetizing and cleaning the work with gasoline, the head and thimble are reassembled and the end *G* is inserted in the bracket *F*, and clamped tight with the screw *D*. The assembled gage is now placed on the magnetic chuck grinder, and the under side of the jaw ground parallel with the bottom of the base.

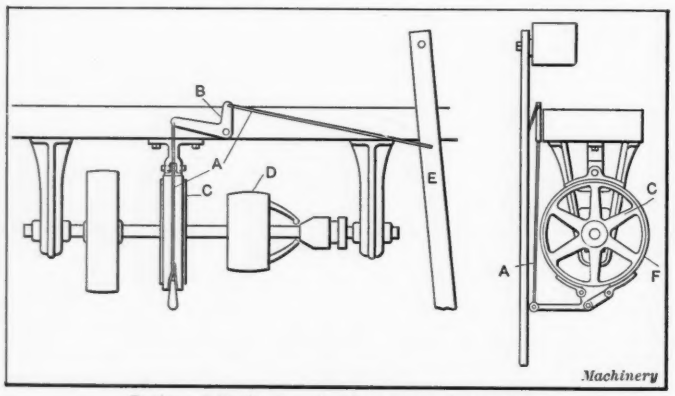
After thoroughly demagnetizing and cleaning, the gage is ready to set up, and this is done as follows: Set the zero line on the bracket to any division on the bar *M* and clamp the bracket tight with the screw *H;* then bring the thimble *L* to register zero at its lowest point, loosen the screw *D* and use a size block or height gage to set the jaw *I* to the height above the surface plate at which the bracket is set on the bar *M*. Now gage the distance between the jaw and the surface plate, adjusting the "mike" by means of the screw *E* until it just touches the gage used; retighten the screw *D*, and the gage is ready to use.

After the head is properly set in the bracket, it is only necessary to change the position of the bracket to coincide with any given line on the bar for the various inch or millimeter settings. The scriber *A* is used to scribe lines or to gage under projections.

New Britain, Conn. WILLIAM C. BETZ

BRAKE FOR HIGH-SPEED LATHE

The accompanying illustration shows a brake which was designed by the writer and recently tried out on a number of "Lo-Swing" lathes. The high speed of the driving pulleys on these machines was responsible for the loss of a considerable



Design of Brake for stopping High-speed Lathes

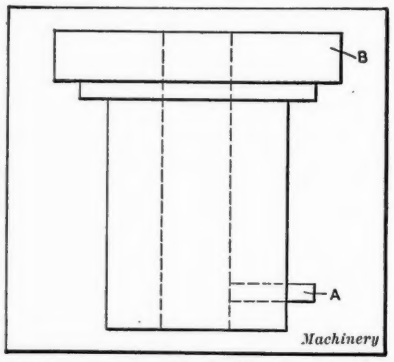
amount of time when it was required to stop them, or else the operator ran considerable risk of accident by attempting to use his hand for a brake. The use of the device illustrated herewith did away with all of these difficulties in a very satisfactory manner.

Referring to the illustration, *C* is a 12-inch pulley, the face of which was turned flat. The pulley was mounted on the countershaft and the brake band *F* was hung from a beam overhead. This brake band embraces the pulley, and the material used in making it was obtained from some discarded automobile parts. Connection between the brake and shifter rod is made by the wires *A* and bell-rank *B*. The adjustment is so arranged that a slight movement of the shifter rod *E*, after the clutch is released, will tighten the band *F* on the pulley *C* and bring the countershaft to a stop. Four of these brakes have been in constant use in the shop for nearly a year and have never given any trouble. Their use enables the lathe to be stopped gradually or instantly if necessary.

Cleveland, Ohio. F. O. SMYTH

SLIP DRILL BUSHING

In the April issue of MACHINERY, a description of a method of securing slip drill bushings was published. The following device is one which the writer believes is superior to that referred to. Here it will be seen that the pin *A* is put near the bottom of the bushing and a 7/32 or ¼-inch hole is drilled right through the jig so that it nearly breaks into the bushing hole. This hole is then cut or filed out so that it connects with the bushing hole. The cuttings force the bushing up somewhat, which is desirable as it makes it easier to remove. After the drill has entered an eighth or more, the bushing is not really needed. Thus bushings can be inserted from either side of the jig, the pin merely being used to prevent the bushing from rotating and wearing the hole out of alignment. It will be seen that a shoulder *B* is provided at the top of the bushing which makes it possible to use a screw-driver to pry it out when necessary.

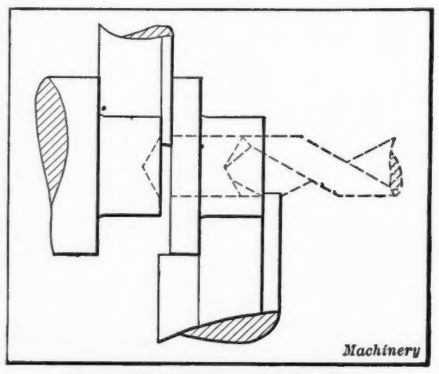


Pin for preventing Jig Bushing from turning

Galt, Ontario, Canada CECIL H. SMITH

FORMING TOOLS FOR ROUGHING AND FINISHING

The illustration shows another method of producing ball bearing cones of the type referred to under this title by Corwin Lamoreaux and Elam Whitney in the January and April issues of MACHINERY. The writer has had considerable experience in designing tools of this type and believes that the present method would enable an increased production of work to be obtained. The advantage claimed for the separate roughing and finishing tools over the long forming tool is, of course, conceded, and this subject was very clearly dealt with by Mr. Whitney. The writer believes that the present method embodies all of the good points of the separate tools and, at the same time, allows the work to be drilled and reamed simultaneously with the forming operation.



Another Method of machining Ball Bearing Cones

Referring to the illustration, it will be seen that the work is roughed out and cut off with the "back tool" but a wall of sufficient strength is left on the side of the ⅜-inch hole (at the time the "front tool" finishes its work) to insure accurate results. The "front tool" can skim down the side of the large diameter at quite a fast feed—about 0.0015 inch per revolution—until it reaches the last thousandth when it can

be slowed down to about 0.0005 inch per revolution to insure a good finish on the work. Operating under these conditions, the chip is light and the feed so slow that there is no danger of distorting the work. As the point of the forming tool which runs through the hole to a depth of 0.010 inch can be fitted into the flute of the reamer, there will be no interference.

The following is the order of operations:

	Rev.	Travel	Feed
Finish-forming	190	0.262	0.0005 / 0.0015
Drill	110	0.660	0.006
Index turret	20		
Ream	60	0.600	0.010
Cut off and rough forming	375	0.375	0.001
Total revolutions	375		

It will also be noted that the "front tool" reaches over the large diameter, thus removing the burr which is thrown up by the cut-off tool when it enters the work. In this way, the piece is dropped from the bar quite finished.

Providence, R. I. JOHN J. MCNIFF

DRILLING HOLES IN GLASS

Mr. O. M. Hance describes a method of drilling holes in glass in the December number. I have found it much easier and quicker to drill glass by hand. Make a dam on the glass with putty or similar material around the spot where the hole is required to be drilled. Fill the dam with turpentine and use for a drill a three-cornered file having the end broken off at that point which will produce the size hole required. Sharpen the end to about 45 degrees making a sharp point. Use this drill in the hands, twisting it back and forth and apply plenty of turpentine. When the point of the drill punches through the opposite side, reverse the glass and finish the hole from the other side in order to prevent breaking out. I have drilled glass ⅜ inch thick in five minutes by this method.

South Bend, Ind. S. QUEER

MEAT HOOK BENDING MACHINE

The manufacture of meat hooks for refrigerator cars is a side line in railway shop work which cannot be overlooked in developing efficient methods of operation. The machine illustrated in Fig. 1 is a labor-saving device for this purpose which has been the means of saving hundreds of dollars every year. The usual method of making all sizes of meat hooks is to bend them over a block by hand, or to use a hand or machine die for this purpose. In using either of these methods, the metal is worked hot and a separate operation is necessary for bending each end of the hooks. The machine which is to be described in this article enables the work to be bent cold and both ends of the hook are formed by a continuous operation of the machine.

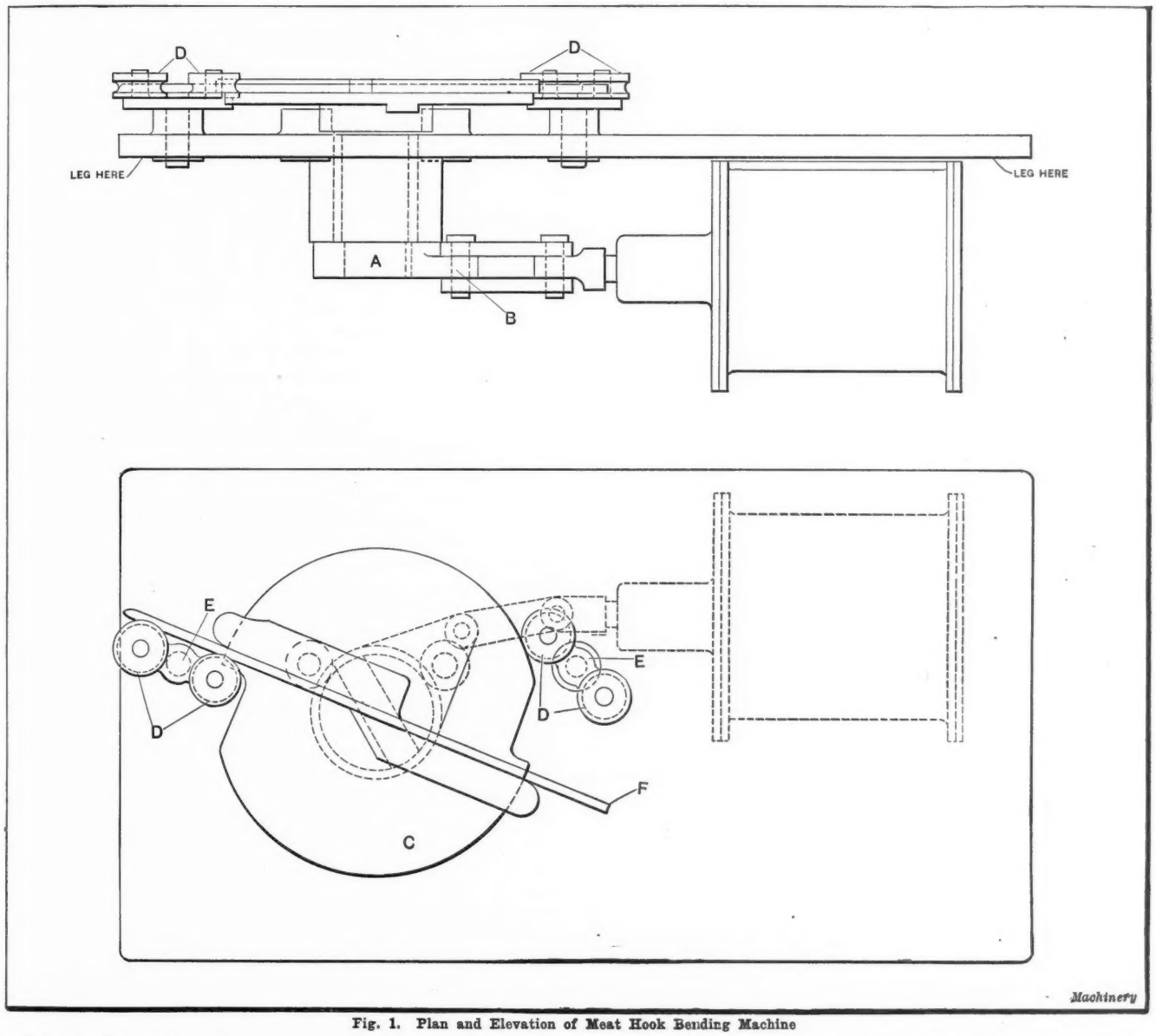


Fig. 1. Plan and Elevation of Meat Hook Bending Machine

This machine consists of an air cylinder and piston which rotates the mandrel *A* through an angle of 110 degrees by means of a suitable system of levers *B*. The top end of the mandrel is slotted to receive the head *C* which is so shaped that both ends of the hook can be formed around it. Two pairs of rollers *D* are mounted on stationary centers in the position shown. These rollers are maintained in a fixed relation to each other but are free to rotate on the stationary center *E*.

In operating the machine, a piece of ⅝-inch rod *F* of the proper length is placed in position, and the rotation of the

head *C* causes the rollers to bend the rod around the die head, as shown in Figs. 2 to 5 which illustrate the successive operations in forming the two ends of the hook. In making larger sized meat hooks, the rollers are taken from the stationary centers and mounted on bosses provided for that purpose at a greater distance from the mandrels *E*. The operation is the same as that described for smaller sized hooks and

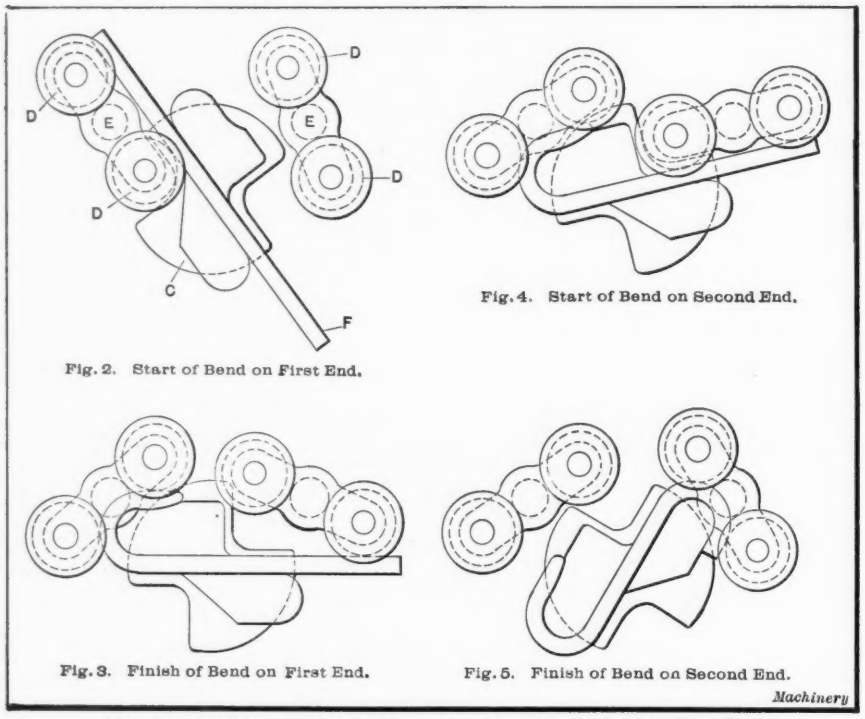


Fig. 2. Start of Bend on First End.

Fig. 4. Start of Bend on Second End.

Fig. 3. Finish of Bend on First End.

Fig. 5. Finish of Bend on Second End.

Figs. 2 to 5. Diagrams showing Successive Operations in bending Meat Hooks

the output of the machine is about 250 hooks per hour, regardless of the size.

West Winnipeg, Manitoba, Canada J. LEE

PROFESSORS OF MACHINE DESIGN—TWO EXTREMES AND THE AVERAGE

It is well that instructors in machine designing rarely feign supreme authority and versatility. If they did they would have hard positions to fill. A fool student, to say nothing of a wise one, can usually ask questions that nobody can answer; hence the frequent embarassment to the would-be authority where questions are asked that *can* be answered.

Occasionally iron-handed masters find their way into colleges, who may or may not be the authorities they pretend to be, yet they manage to retain the respect of their pupils by ignoring queries and continuing with lectures that are usually well emblazoned with intricate formulas. In fact, the writer was often present at lectures (not only in machine design) where neither he nor any other pupil present could have broached a sensible question bearing on the subject in hand because the lecturer did not make clear to us the points at which he was driving. To say one word would be an admission of ignorance and would spell "flunk" for the information seeker.

This type of "deep" lecturer commences his "one-hour-straight" in about this fashion: "The modulus of elasticity of cast iron being widely variable with different grades of the metal, we find it difficult to develop a precise rational formula for the curved beam we are designing to-day, which is subject both to tensional and bending stresses. In fact cast iron is not a strictly elastic metal anyway. However, by plotting the modulus figure, by noting the close approach of its outlines to the parabola, and by the application of a little simple calculus, we obtain this result * * *"

He would immediately cover the blackboard with figures, curves, unfathomable sketches of three dimensions (occasionally he would refer to the fourth dimension to further entangle us, but in justice to him I will say that he never attempted to plot that dimension), and with drawn features and wrinkled brow that forcefully portrayed the mathematical depths he had reached, the professor smote out his lecture while we, who were quickly disinterested, copied what he wrote on the blackboard and patiently waited for the hour to end. His method was to take us by surprise at the very beginning and snow us under with a carefully wrought sentence just as a football team in the early stages of a game plays the opposing team off its feet if possible. After that he seemed to be content and cared naught for himself or for us. When he saw that we were stupefied his face lit up. It would be difficult to conceive of lectures more droll.

Most minds, especially the minds of students, lag far behind the lecturer. Time is required to grasp the full meaning of a new subject. A slow lecturer who can produce a mind that leads, who can keep the majority of his class interested, who drives every argument home with simple, interesting illustrations, and who can thus clarify the most perplexing problems, is a rarity.

The superiority of the "slow" instructor in machine design was first brought to my attention a few years ago. I attended a well-known American university for the sole purpose of specializing in machine design. I frequently asked the professor in charge point-blank questions concerning problems over which I had often pondered. Except in the simplest cases I always received an indefinite reply and usually annoyed the professor. "The method developed by ——" he said at one time in answer to my query, "gives results for the design of crankshafts that are generally accepted in practice." I expressed a desire to have the theory of crankshafts explained, but the professor suddenly engaged himself busily elsewhere and I learned no more about crankshaft design than I knew before. The design of thick cylinders was this man's hobby and he kept us everlastingly at it. Later I went to a smaller Western college and had occasion to take some design work under a man who was slow but thorough. I brought up the crankshaft proposition and he admitted little knowledge of its niceties but immediately offered to assist me to the best of his ability. We dug into the theory, designed, redesigned, compared with common practice, and presently discovered why empirical and standardized processes are generally used. I was satisfied, and now feel that my knowledge of crankshafts is a little above the average. The slow teacher produced in me a leading mind. He was pleased to offer suggestions, to carefully explain the knotty places, and check my results. I noticed that in lectures before his classes this teacher would often make errors—purposely I believe in order to maintain the interest of his class. He required the men under him to check his figures constantly, and, more important still, he wanted them to *understand*. Teaching seemed to be his natural gift, but whether it is a fact to be deplored or not, he is still in the same small school, on the same small salary, and will perhaps spend the balance of his life there. His methods would be unsuccessful in a large college where more bluster and better presence are prerequisites.

Luckily for the student of engineering the average instructor usually confines himself and his class to problems that are tangible mathematically. Simple tensions, compressions, and bending moments in bolts, boiler plates, structural members, etc., constitute the principal course in design, and if the course is thorough in these basic principles, with an occasional careful wandering into something a little more involved such as sizes of pipe for steam, water and gas, intricate cam design, and a little precise gear designing, or some side line of which the teacher is a real master, the instructor may consider his work well done.

The college man who understands and can apply all that has been taught throughout his course, be those teachings ever so simple, has an obvious advantage over the man who has been taught nothing but intricacies and is not sure of any of them.

New York City. W. F. SCHAPHORST

CROSS-DRILLING ON A B. & S. AUTOMATIC WITHOUT STOPPING THE SPINDLE

The operation of cross-drilling the piece *B*, Fig. 1, on a B. & S. automatic is interesting because it must be accomplished without stopping the spindle, and since this piece

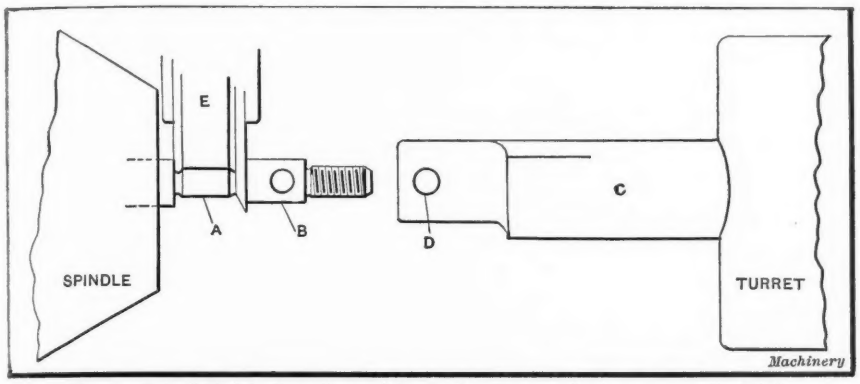


Fig. 1. Cut-off Tool in Operation and Supporting Fixture about to engage the Work

is a screw, it will be understood that both pulleys of the screw machine are in use for threading, making it an impossibility to stop the spindle—hence the novelty. The writer has seen this fixture in operation in a shop where he was formerly employed, and will endeavor to explain the order of operations by means of the accompanying illustrations.

First, it will be noticed that for the particular job in question, a combination cut-off and forming tool *E* is used, as shown in Fig. 1. The only special fixture needed for this job is a sort of jig, which is held in the turret as shown at *C*. Fig. 2 shows two views of this fixture. By referring to Fig. 3, which shows the cams, it will be seen that just before the cut-off blade has severed the piece *B* from the bar stock, advance to its working position, the drill being guided to the work by the hole *D*.

When the cross-drilling is accomplished the front slide recedes, and the jig is tripped away, allowing the cross-slide tool to advance again to form the shoulder *A* on the next piece ready for threading, which is done immediately on the return of the cross-slide tool to its idle position. The main object in using this method is the saving effected through not having to handle the work twice to complete the operations on it, and it also eliminates the cost of a drill jig on the drill press. In Fig. 2, the pieces *O* and *P* can be made with this set of cams, but a change of the drill fixture is necessary to accommodate the size of the work and position of the cross-drilled hole. The pieces *L*, *M* and *N* can be made on a screw machine, using only one pulley and a B. & S. spindle brake on the other pulley to stop the spindle while cross-drilling, but this would not be necessary, although for *M* and *N* a different set of cams would be used, because of drilling in the latter case and knurling in the former.

J. HARMON

CURTAIN FOR COVERING DRAWING-BOARD

Covering and uncovering a drawing-board with a cloth or newspaper is very little work, but most draftsmen and engineers will leave the board uncovered rather than to take this trouble. A better way is to provide an opaque roller shade, such as is used for windows, and attach it to the back of the board. The roller is fastened a little below the upper edge of the board so that it will be out of the way of the tee-square. If the engineer or draftsman is suddenly called away

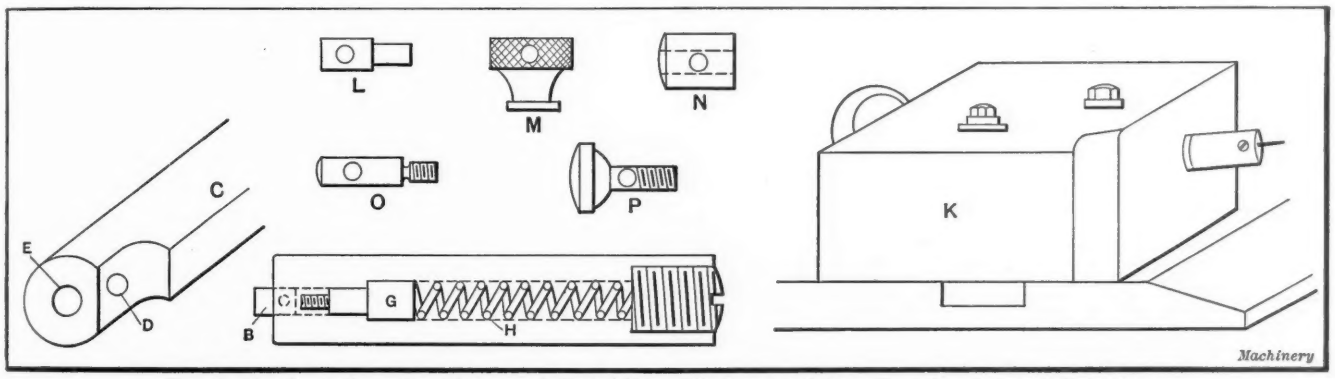


Fig. 2. Details of Supporting Fixture and Cross-drilling Attachment and Some Examples of Cross-drilled Pieces

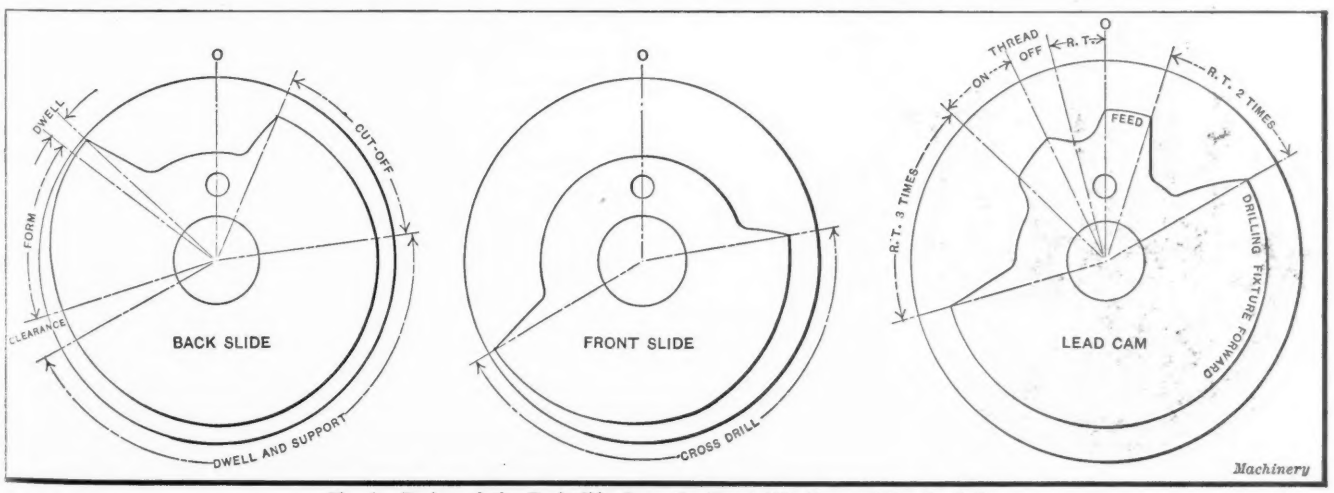


Fig. 3. Design of the Back-slide Cam, the Front-slide Cam and the Lead Cam

the fixture *C* is tripped and advances to the work. The hole *E*, Fig. 2, admits the head of the screw, and the turret is brought forward far enough so that plunger *G*, by the action of coil spring *H*, holds the piece *B* against the cut-off blade when entirely severed from the bar. It will be noticed that the cut-off tool remains in this position without advancing further, so that the cross-drilling attachment, *K*, Fig. 2, may

he usually does not take the time to cover up his board, leaving his work exposed to the dust, but with the roller shade attached to the back of the board it takes but a half second to cover up the work. In the morning or when the engineer returns to his work all that is necessary is to raise the shade and the work is as fresh and clean as before.

Chicago, Ill. O. M. HANCE

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW DESIGNS AND IMPROVEMENTS
IN AMERICAN METAL-WORKING MACHINERY AND TOOLS

BOSTON GEAR HOBBING MACHINE

The gear hobbing machine illustrated herewith is being built by the Boston Gear Works, Norfolk Downs, Mass. This machine has a capacity for hobbing spur and spiral or helical gears up to 12 inches in diameter. Gears up to 6 pitch may be hobbed in steel and up to 5 pitch in cast iron. The machine can also be used for producing worm gears up to 12 inches in diameter, but in the case of worm gears, the feed is not automatic. Single-thread worms or screws up to 12 inches in diameter by 24 inches face can also be cut.

All of the gears on this machine are constructed to provide adjustment for wear, and in this way any backlash which would affect the accuracy of the cutting mechanism can be compensated for. The main work spindle and cutter spindle have taper bearings, thus providing an easy method of adjusting for wear. In designing this machine an effort was made to have it equally adaptable for cutting gearing as fine as 48 diametral pitch and less than 1 inch in diameter, and steel gears as heavy as 6 diametral pitch with the hob working up to its full capacity. Referring to the illustrations, it will be evident that much of the rigidity of this machine is due to the small amount of overhang of the cutter shaft. On the machine shown, the overhang does not exceed 4½ inches from the ways.

The design has also been simplified as far as possible, thus making the machine efficient and easy to operate. There

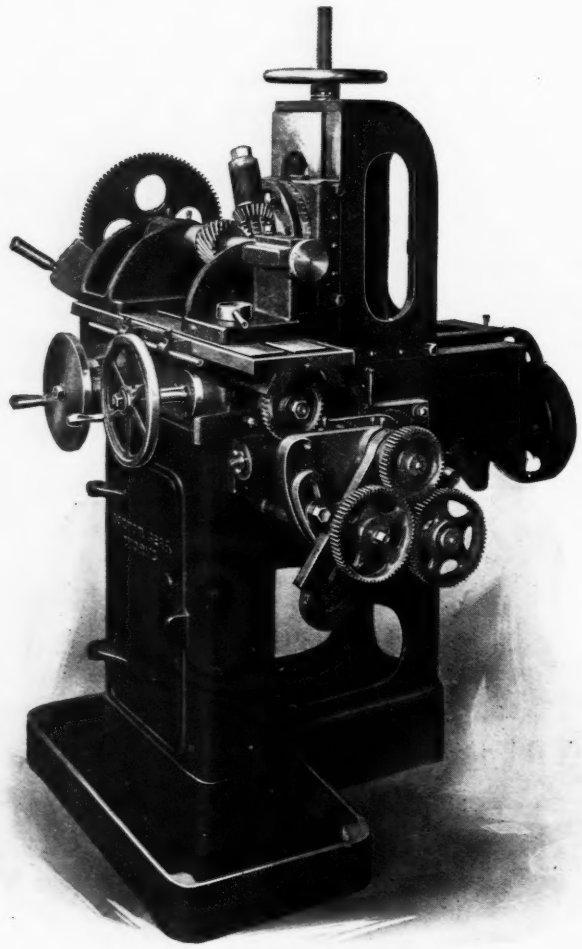


Fig. 1. The Boston Gear Generator

are only two driving members in the cutter head. In the illustration Fig. 2, it will be seen that there is a screw arrangement on the back end of the shaft connected with the large bevel gear which provides for making adjustment toward the bevel pinion. This enables any backlash between these two gears to be compensated for. The arrangement of the other gears in the driving train has been worked out with the view of reducing backlash to a minimum. As a result, any tendency toward chatter in the gearing has been practically eliminated, thus increasing the accuracy and efficiency of the machine.

Another distinguishing feature is that the hob is held practically vertical when in the cutting position, and in cutting the ordinary type of gear this allows chips to clear them-

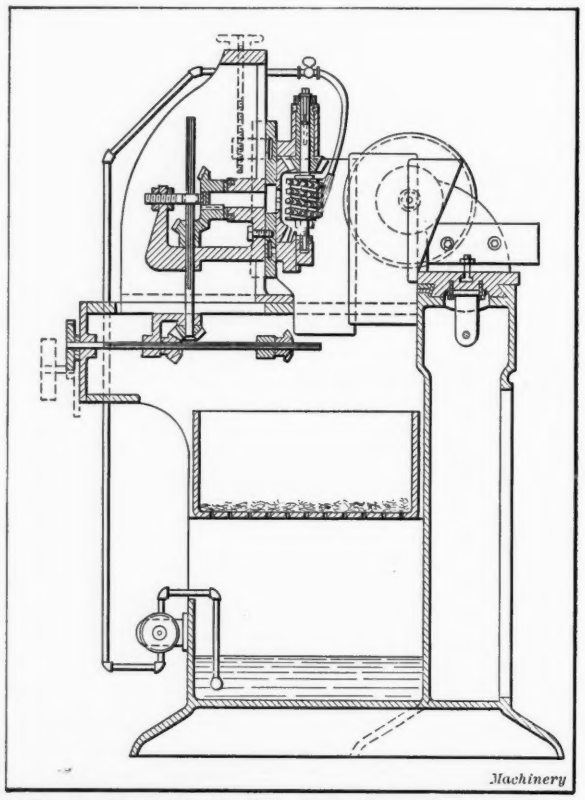


Fig. 2. Cross-sectional View of the Boston Gear Generator

selves much better than they would if the hob was on top of the gear or the gear on top of the hob. An arrangement for taking care of the chips below the machine is provided, which enables the oil to be drained to the reservoir from which it is returned to the cutter by means of a suitable pump.

The worm-gear index is accurately cut and all of the bearings in the machine are ground with oil grooves to provide for proper lubrication. All parts of the operating mechanism are conveniently located. The handwheel located at the left of the machine is provided with a micrometer dial for bringing the cutter head to the required position and securing the necessary depth of cut. The handwheel on the right-hand side of the machine is used for returning the cutter slide at the completion of the cutting operation. A quick return movement is provided for this purpose.

The machine is provided with a constant-speed, single pulley drive, the speed variations being obtained by a change gear device shown at the right-hand side of the machine. The change gears for both speed and indexing are conveniently located, gears being furnished to provide for cutting any number of teeth up to 100, and by compounding, even numbers can be obtained up to the usual requirements over 100. The driving pulley is 12 inches in diameter by 3 inches face and runs at a speed of 320 revolutions per minute. Ten changes of hob speeds are provided, which cover a range from 40 to 400 revolutions per minute. A special attachment can also be furnished which gives hob speeds up to 1200 revolutions per minute. The range of feed runs from 0.010 to 0.160 inch per revolution. The work spindle is provided with No. 10 B. & S. taper. The total height is 60 inches and the floor space occupied 40 by 50 inches. The net weight of the machine is approximately 1600 pounds.

WATERBURY FARREL WIRE SPOKE MACHINES

The machines illustrated and described in the following have been designed and built by the Waterbury Farrel Foundry & Machine Co., Waterbury, Conn., for heading, bending and threading wire wheel spokes for automobiles, motor cycles and wagons. Fig. 1 shows an open-die, single-stroke header for heading and bending spokes. This machine is built in different sizes for heading and bending spokes up to and including ¼ inch in diameter. The bending attachment is mounted on the top of the machine and consists of suitable bending tools operated from the crankshaft.

The machines are driven by a flywheel mounted directly on the crankshaft, which is of ample size to furnish the required amount of power and runs in suitable bearings. Owing to the fact that these machines are hand fed and that the operator depresses and releases the treadle, causing the machine to make one revolution and come to a stop for each blank that is headed, the capacity in blanks per minute depends largely upon the skill of the operator. Some operators are able to run the machines almost continuously.

The heading slide is designed so that it is positively operated in the bed during its forward motion by a connection on

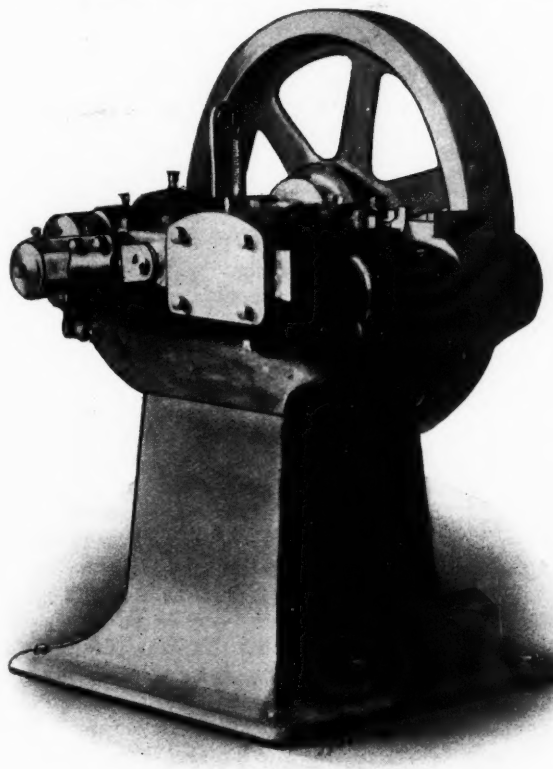


Fig. 1. Waterbury-Farrel Wire Spoke Heading and Bending Machine

the crankshaft, but so arranged that the gate is pulled back by a spring that brings it up against an adjustable stop-screw. To regulate the amount of stock in the upset, this adjustable stop-screw can be set so that the heading slide will stop with the punch at the required distance from the dies, thus acting as a feed stop for the wire and insuring the correct length of wire projecting from the dies to form the upset.

The punch is held in an adjustable punch-holder in the end of the heading slide and may be adjusted up and down, from side to side, and also toward and away from the dies, which provides for having the punch centrally located with the dies. The gripping dies are made of hardened and ground tool steel; one die is held in a stationary die block, and the other in a sliding die block, which is operated by a toggle motion and connection from the crankshaft.

In operating the machine, the spoke to be headed is placed between the open dies and pushed forward until its end comes into contact with the punch, which acts as a feed stop, thus assuring the correct length of wire projecting from the dies to form the upset. The heading slide then advances the punch upsetting a head on the end of the spoke. The headed spoke is then taken from the top of the machine and inserted in the bending die at the left, where the bending tools operate, bending the spoke to the required shape.

Fig. 2 shows a reciprocating screw thread rolling machine of the side feed type, which is used for rolling the threads on the ends of the spokes. The machine is built in sizes suitable for threading spokes up to and including ⅜ inch in diameter. This machine is similar in design to the standard screw thread rolling machines built by this company, but as the work is too

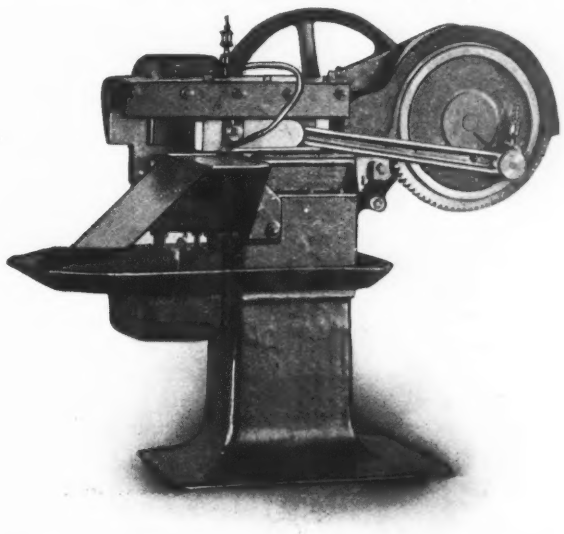


Fig. 2. Waterbury-Farrel Reciprocating Screw Thread Rolling Machine

long to be handled in the standard machines, this machine was designed to receive the work from the side and is fed by hand.

The machine is driven by heavy pulleys and is back-geared to give a powerful drive. The gears, pitman and all parts are well protected by guards for the safety of the operator, as shown in the illustration. As the machine is fed by hand, the number of blanks that are threaded per minute depends largely upon the skill of the operator in feeding the work.

The dies are arranged so that the work is rolled in a horizontal position, thus allowing long work to be readily handled. The arrangement and adjustment of the dies is the same as on the standard type of thread rolling machines of this company's manufacture. The reciprocating or moving die is longer than the stationary die. The dies are held in position by clamps and may be easily removed when desired. The reciprocating gate or slide which carries the moving die is mounted in a dovetail slide and held in position by a cap, which has provision for taking up wear. The stationary die-holder is adjustable for any diameter of work within the limits of the machine.

In operating the machine, the blanks to be threaded are placed against a set edge on the table bracket which projects

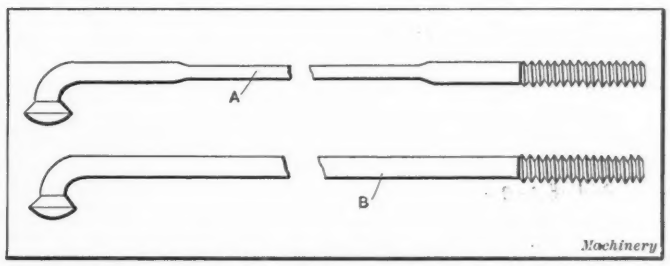


Fig. 3. Swaged Spoke A with Cut Thread; Spoke with Rolled Thread at B

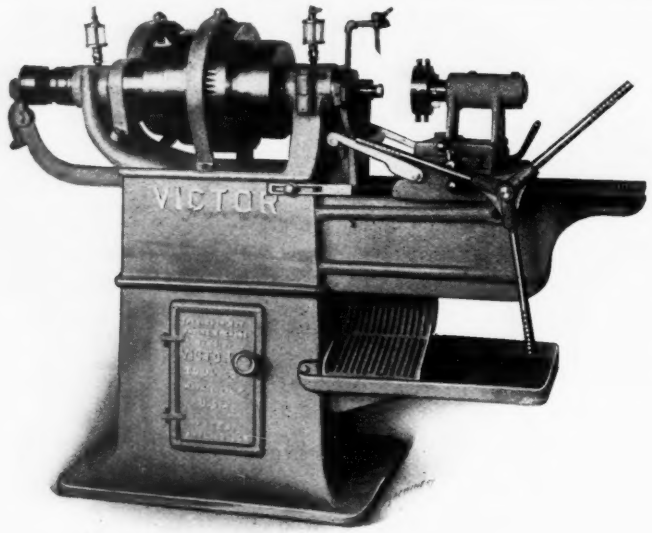
in front of the machine. As the gate is drawn back, the operator places the blank in position against a depth gage, which may be adjusted to give any length of thread that is desired within the limits of the machine. A "pusher" or starting slide automatically carries the blank to the dies at the correct time. The blank is then rolled and falls off the end of the die into a suitable receptacle placed on the floor to receive the finished work.

An oil tank, pump and suitable piping are furnished with each machine, which provide an ample flow of oil or other lubricant for the work and dies, thus keeping the dies cool

and clean. Fig. 3 shows two spokes which have been headed, bent and threaded. Rolling the thread increases the diameter of the wire at the threaded section. For rolled threads, a wire of the pitch diameter of the required thread is used. The spoke illustrated at *A* has been swaged and has a cut thread, while the spoke at *B* has a rolled thread, the increase of diameter of the threaded section being somewhat exaggerated in the illustration. Both spokes were headed and bent on the same machine. Where the spokes are to be swaged—that is, reduced in diameter between the ends—this is done on other machines.

VICTOR NUT FACING MACHINE

The improved nut facing machine which is shown in the accompanying illustration is a product of the Victor Tool Co., Waynesboro, Pa. This machine is designed for facing nuts which are screwed onto the end of the spindle ready to be operated upon by a tool carried by the tool-carriage. The operation of the machine is exceedingly simple and its design insures having a nut faced true with the thread. The operator feeds the machine with his left hand and uses his right hand for operating the tool-carriage. The method of procedure is as follows: Taking a nut in his left hand he places it on the revolving spindle of the machine, where it is engaged by the thread and screwed into place. The capstan handle is then



Victor No. 2 Nut Facing Machine

turned to bring the facing tool into operation and the provision of suitable stops insures having each nut faced to the same thickness. After the facing operation has been completed, the capstan handle is turned to the right. This traverses the carriage to the right and engages a clutch on the spindle which rotates it in the opposite direction to back off the nut. The nut drops from the spindle and slides down the metal chute shown in the illustration, which discharges it into a box placed on the floor for that purpose. When the operator releases his grip on the capstan, the action of the spring at the left-hand end of the spindle draws the spindle back by means of the link which runs through the bed of the machine to the yoke at the right-hand end of the spindle. This engages a clutch which drives the spindle forward ready to have another nut screwed into place to be faced.

The machine is equipped with a pump, unless otherwise specified, and the use of a cutting compound is recommended. Referring to the illustration, it will be seen that the machine is driven by a three-step cone pulley and back-gears which provide six operating speeds. For facing ⅜- to ⅝-inch nuts, a speed of from 300 to 350 revolutions per minute is recommended, lower speeds being used in proportion to the size of the face. The principal dimensions of the machine are as follows: Height 48 inches; over-all length 64 inches; size of base 22 by 32 inches. The spindle bearings are bushed with babbitt and provided with means of adjusting for wear. The diameter of the front bearing is 3 inches and of the rear bearing, 2¼ inches. The cone pulley diameters are 11 inches, 8½ inches and 3¾ inches by 3-inch face. The net weight of the machine is 1400 pounds.

HJORTH BENCH LATHE ATTACHMENTS

The Hjorth Lathe & Tool Co., (Woburn), Boston, Mass., has developed a number of attachments for use on the bench lathes of its manufacture. These attachments are of material assistance in widening the scope of a bench lathe, and by referring to the illustrations, it will be evident that a great variety of

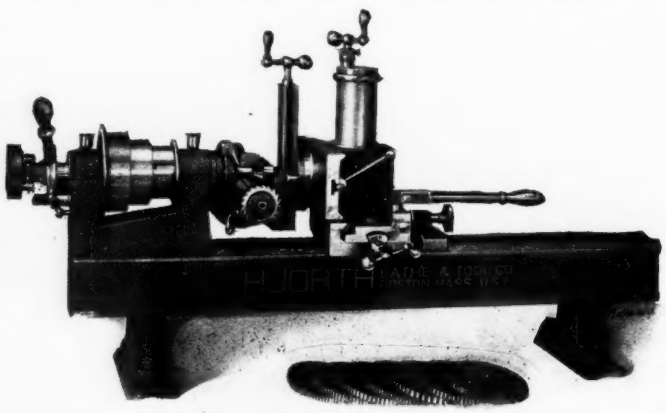


Fig. 1. Hjorth Bench Lathe equipped with Plain Milling Attachment

work can be handled by a machine provided with all of these subsidiary equipments.

Fig. 1 illustrates a Hjorth bench lathe equipped with a plain milling attachment. This attachment is designed with combination lever and screw feed and is adapted for milling gears, milling cutters, reamers, taps, and similar classes of work. The attachment is adapted for using the same type of spring chucks that are used in the lathe headstocks and this makes the chucks of the lathe and milling attachment interchangeable. The cylindrical post provides a particularly rigid support and the vertical screw affords a means of setting the shoe-block at a suitable height for the class of work that is being handled. The shoe-block is graduated in degrees, so that it may be set to any required angle for cross or angular milling; this makes the shoe-block independent of the lower slide. A key, inserted through the shoe-block, is held on the cylindrical post by means of two taper-headed screws which enable the block to be raised or lowered without throwing it out of alignment with the lathe bed. When the attachment is to be used for angular milling, the key is loosened and the taper screws removed. The vertical movement of the attachment on the cylindrical post is 3½ inches and the cross movement, 3½ inches. A special slide is made to be fastened on the shoe-block by means of an eccentric binder. This slide provides a movement of 5½ inches. Both the swivel quill holder and the

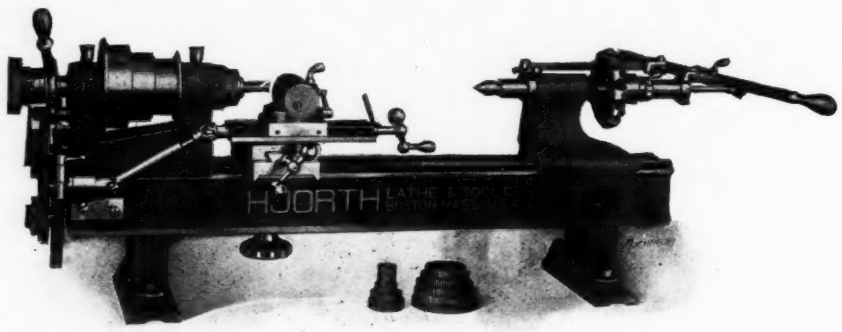


Fig. 2. Screw-cutting Attachment for Hjorth Bench Lathe

slide swivel are graduated in degrees and can be firmly tightened with two T-slot bolts. A swivel vise is made for use in connection with this milling attachment, which has been found to add materially to the efficiency of its operation.

A lathe is shown in Fig. 2 equipped with a thread cutting attachment. Referring to the illustration, it will be seen that

the screw of the compound rest is connected with the change-gears by means of a universal jointed driving rod. The change-gears supplied with the lathe give the attachment a range for cutting screws having from ten to eighty threads per inch.

Fig. 3 shows one of the Hjorth lathes equipped with a universal milling attachment, the machine being engaged in milling a rack. It will be seen from the illustration that the ball-

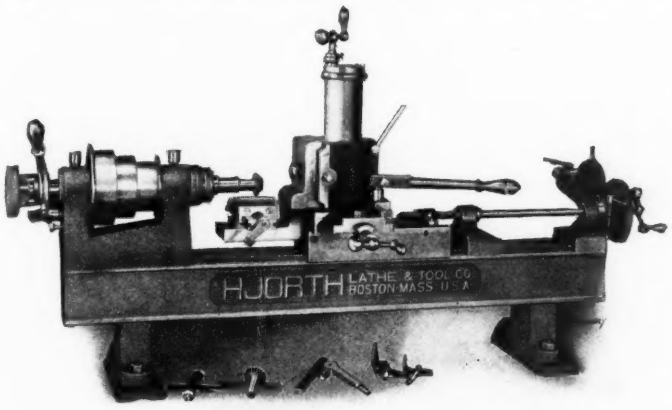


Fig. 3. Universal Milling Attachment for Hjorth Bench Lathe

crank at the top of the cylindrical post provides the vertical movement for the attachment. Longitudinal travel is secured through the threaded rod running parallel with the lathe bed, and transverse movement through the ball-crank which operates the slide. The work is held in a vise carried on the extension of the attachment, and the construction

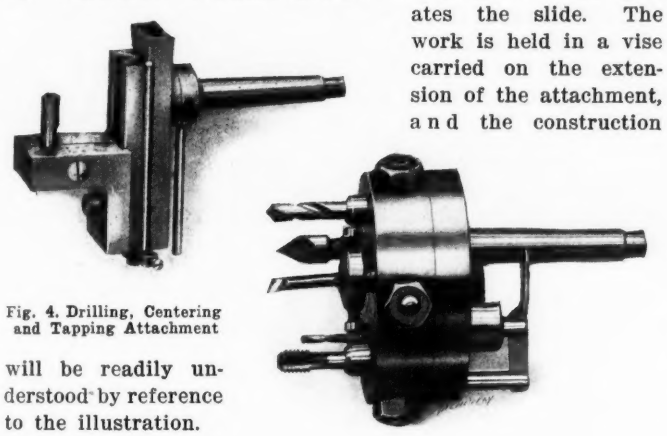


Fig. 4. Drilling, Centering and Tapping Attachment

will be readily understood by reference to the illustration.

A combination drilling, reaming and centering attachment for the Hjorth bench lathe is illustrated in Fig. 6. The taper shank of this attachment is mounted in the lathe tailstock. This shank carries an off-set arm upon which the tool-holder attachment is pivoted. The illustration shows the tool in position for centering; after this operation has been performed, the tool is swung over to bring the drill into the line of centers when the drilling operation is performed. The same attachment can be used for a variety of classes of work where two operations must be performed.

Fig. 5. Turret Attachment for Hjorth Bench Lathe

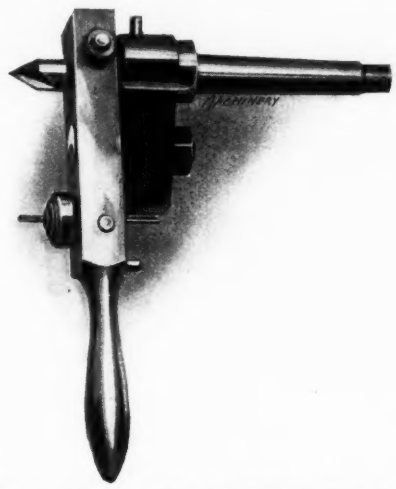


Fig. 6. Hjorth Combination Drilling, Reaming and Centering Attachment

A turret attachment having a capacity for five tools is illustrated in Fig. 5. Like the preceding attachment, this tool is fastened to the lathe by a taper shank fitting into the lathe tailstock. It will be seen from the illustration that a latch is provided which is controlled by a suitable lever. After each successive operation has been completed, the latch is released and the turret indexed into position for the next operation. It is then secured in this position by the latch.

Fig. 4 shows the adjustable V-block center, with an angle-iron attached, set up for drilling, a central stud being provided to hold and center the work. Referring to the illustration, it will be seen that the block has a cross-slide movement and that it can also be lowered and raised; when in the desired position, it is held in place by means of a T-slot and lock-nut on the shank. By removing the angle-iron, the stop rod on the side of the attachment can be placed in the groove of the V-block, adjusted and locked in place to serve as a means of locating successive pieces in the same position for drilling.

STOPS FOR HARDINGE BENCH LATHE TURRET HEAD

The accompanying illustration Fig. 1 shows a new form of independent stops for a bench lathe turret head which has been brought out by Hardinge Bros. Inc., 3133-3141 Lincoln Ave., Chicago, Ill. It will be seen that the turret has a capacity for six tools and that there are six stops—one for each tool. The advantage of such an arrangement will be readily apparent, as the length of the shank of each tool can be made entirely independent of that of the other tools in the turret.

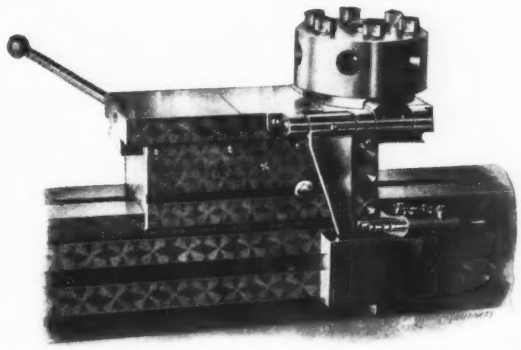


Fig. 1. Independent Stops for Hardinge Bench Lathe Turret Head

In operating a Hardinge bench lathe turret attachment provided with these independent stops, the part which engages with the stops is moved out each time that the turret is indexed for a new operation. In this way, the part is automatically brought into position to engage with the stop corresponding with the tool which is about to begin work.

Fig. 2 shows a No. 4 Hardinge bench lathe which is made with a 9-inch swing and provided with an off-set tailstock.

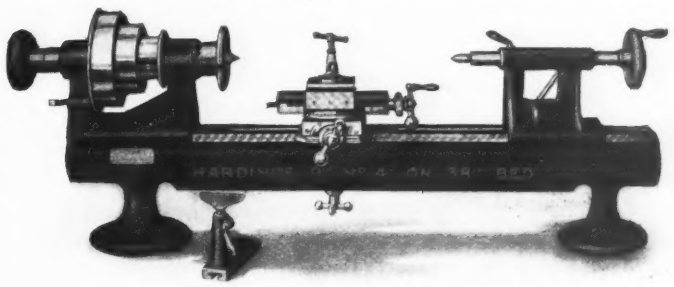


Fig. 2. Hardinge No. 4 Bench Lathe with 9-inch Swing

Hardinge Bros. have recently increased the swing of their Nos. 4 and 5 lathes from 7 to 9 inches to meet the demand for a heavy bench lathe equipment for use in manufacturing plants where work requiring machines of this size is being handled. A new compound slide rest of heavier design has also been brought out for use on these machines.

GRAHAM DRILL SPEEDERS

The Graham Mfg. Co., Providence, R. I., has brought out a new line of drill speeders or high-speed drilling attachments, which are for use on the larger sizes of drill presses where small holes are to be made. The general advantage of these speeders is that they convert a slow-running drill press into one of high speed, thus saving the cost as well as the space required for an extra high-speed machine. A large drill works at a disadvantage in making small holes for oil, dowel pins, etc., unless some speed increasing device of this nature is

used. These attachments are intended for use on all drilling machines from the 20-inch size up to the largest radial. Few large machines are speeded sufficiently fast for drills under ⅝ inch, and radials naturally run still more slowly. The idea of trying to run machines of heavy design at the high speeds required is not good practice; the bearings are too large, the gears would make too much noise under such operating conditions, and too much vibration would be set up in the vicinity of the machine.

Referring to the illustrations, Fig. 1 shows the type of speeder most commonly used. It is made in three sizes, accommodating drills up to ¾ inch diameter. Fig. 4 shows a cross-sectional view and Fig. 3 the entire moving parts. It will be seen that the shank is of the regular taper type and has a casehardened gear fastened to it. This gear meshes with two pinions mounted on casehardened studs. A pair of gears are fastened to these pinions, which, in turn, mesh with the spindle pinion from opposite sides. The spindle and pinion are machined from a single piece of hardened tool steel. At the bottom, the spindle is fitted to a chuck, or it may be extended downward and a hole made in it to receive a taper shank drill, as shown in Fig. 2. The arrangement of the gearing balances practically all strain in the mechanism and there is no end-thrust transmitted through the case. A ball bearing is placed on a wide shoulder at the bottom of the shank, and the top of the spindle is below the ball bearing, so that there is nothing intervening but the ball bearing between the pressure applied to the shank from above and the pressure delivered to the spindle, chuck and drill below. This arrangement is clearly shown in the sectional view Fig. 4.

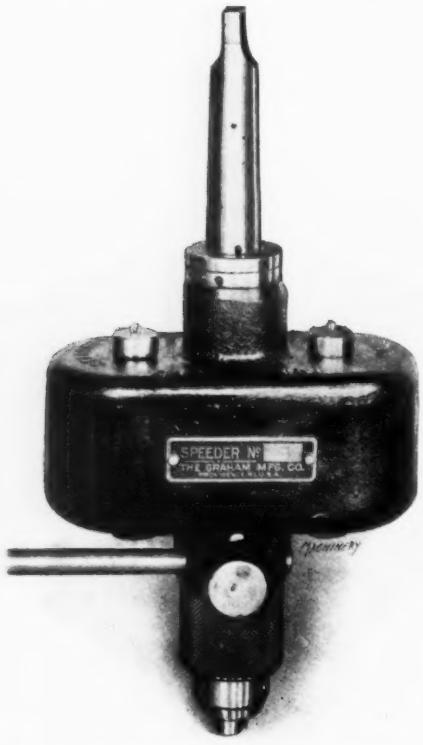


Fig. 1. Most commonly used Form of Graham Drill Speeder

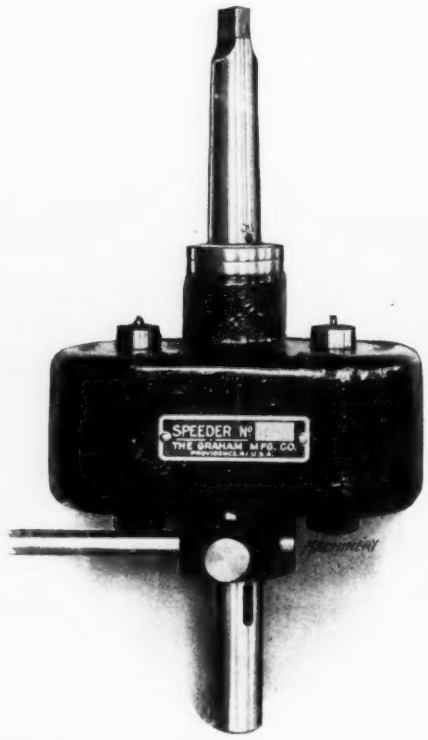


Fig. 2. Graham Drill Speeder designed for Taper Shank Drills

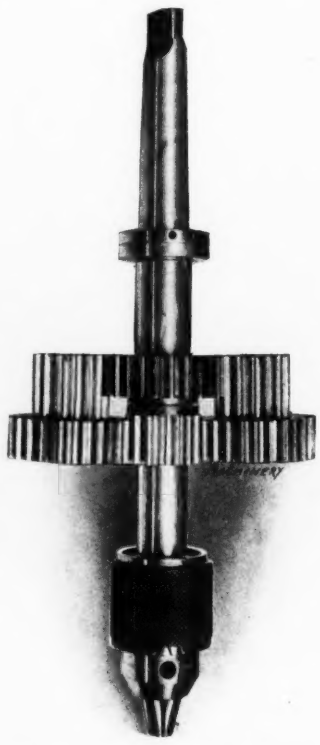


Fig. 3. Mechanism of Drill Speeder shown in Fig. 1

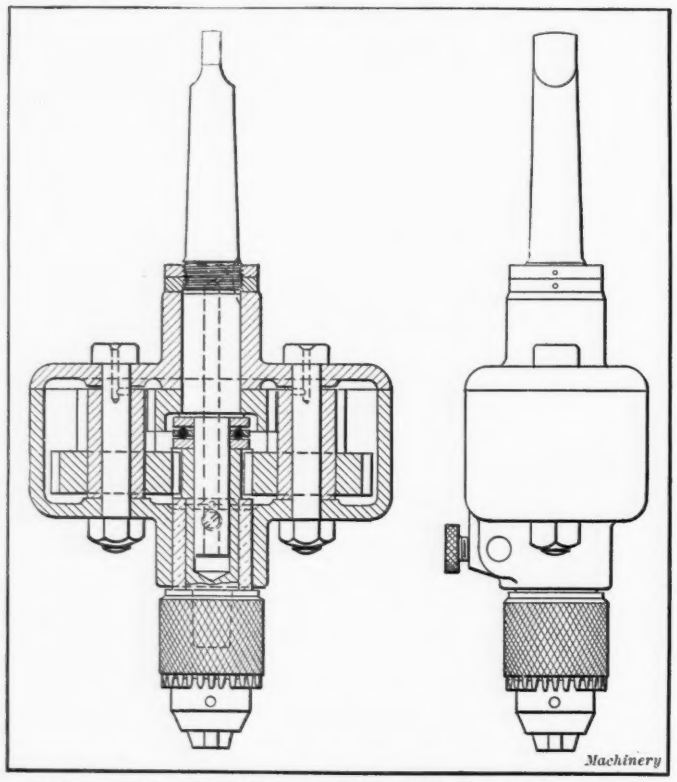


Fig. 4. Cross-sectional View and Outline of Speeder shown in Fig. 1

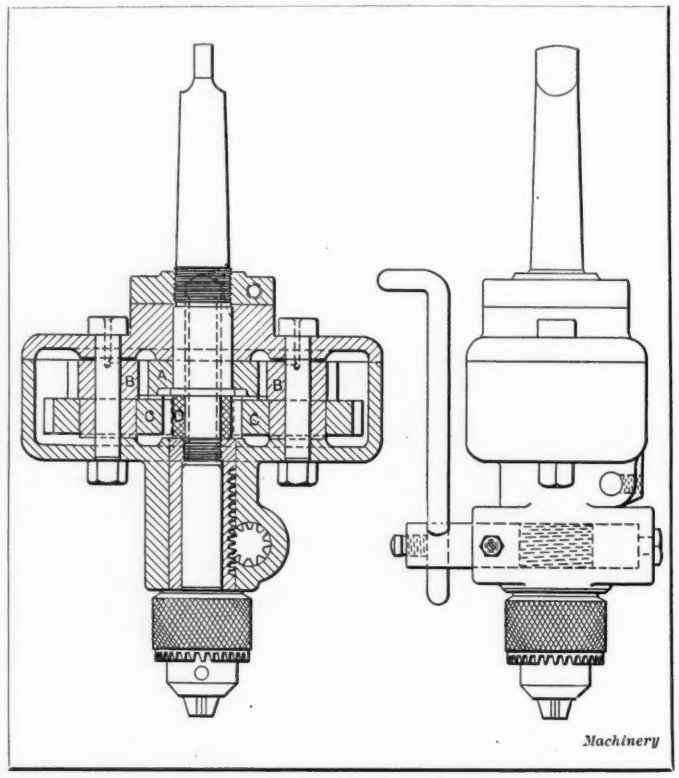


Fig. 5. Cross-sectional View and Outline of Speeder shown in Fig. 6

The matter of having perfect alignment is of great importance. This feature has been provided for by reducing the

lower end of the shank and extending it downward until it is almost even with the top of the chuck. This extension, or tail, forms a long bearing inside the spindle. Further support is given to the spindle by a bushing on the outside; this bushing is also made to take up any end wear that may develop. The two studs upon which the intermediate gear clusters are mounted also serve to hold the case together. The case must not revolve, and a bar to keep it from doing so extends to the column of the machine, or some other rigid piece of a similar nature; or the bar may be held by hand.

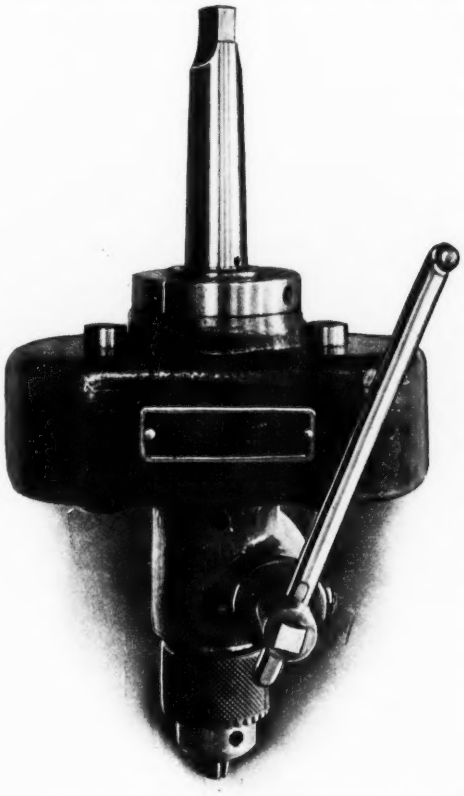


Fig. 6. Graham Drill Speeder provided with Sensitive Feed Mechanism

The device described in the foregoing is simply a speed increaser, and must be fed by the regular feed mechanism of the machine. It is made for hard service in regular manufacturing. Fig. 6 shows another type of speeder with a sensitive feed lever. This means that the main feed mechanism of the machine can be set at any desired point and locked, and that the actual feeding of the drill can be accomplished by a mechanism within the speeder. This style is not intended for heavy, constant or manufacturing service. It should be kept in the tool-room for use on all classes of fine drilling, such as making holes to lines, making templets, jig holes, lay-outs, dies, oil holes, pin holes, etc. The feed mechanism of the main machine is not usually sufficiently sensitive to the touch; hence the necessity of a spring return feed lever on the speeder itself.

In a general way, the driving mechanism is the same as that of the regular type of speeder which has been described. The speed is increased three times, and the gearing is arranged

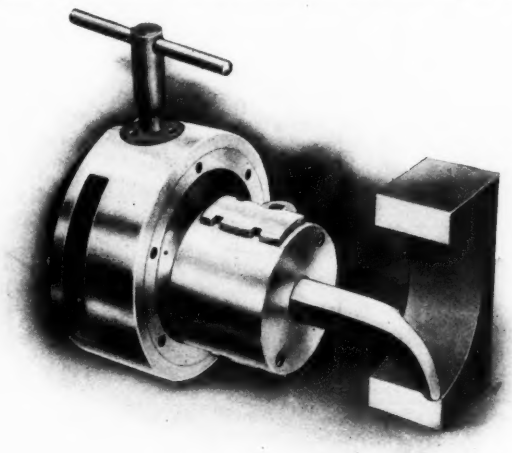


Fig. 1. Marvin & Casler Offset Boring Head

according to the previous description. The spindle is driven by a bronze gear, broached to suit splines on its upper end. It extends upward into the shank for alignment, as well as to provide the necessary length for the required end motion. In order to get vertical traverse, the spindle is mounted on a bronze racked sleeve. Into the rack there meshes a pinion, to which is fastened the return spring and the feed lever. This feature, as well as an entire section and outline is shown in Fig. 5.

MARVIN & CASLER BORING BAR

In the March, 1909, issue of MACHINERY, the offset boring head made by Marvin & Casler Co., Canastota, N. Y., for use on milling machines, drill presses, boring mills and lathes, was illustrated and described. This company has recently brought out a new boring bar for use in connection with this head, the object being to adapt a milling machine for handling many

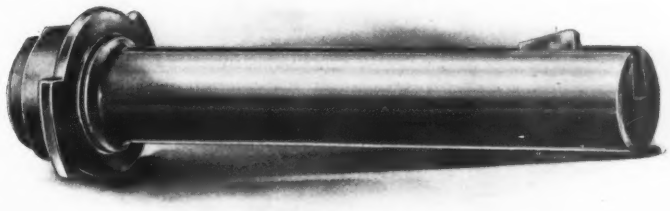


Fig. 2. Boring Bar for the Marvin & Casler Offset Boring Head

classes of boring operations on jigs and irregular shaped machine parts which are usually performed on a lathe. The boring head is shown in Fig. 1, and Figs. 2 and 3 show an assembled boring bar and the parts of the bar, respectively.

The boring head is usually arranged to be screwed onto the threaded nose of the milling machine spindle. Fig. 1 shows the head with the chuck set off center by means of the graduated screw, in order to enable the tool in the chuck to bore a hole of the required size. If desired, the chuck can be brought concentric with the head to enable an ordinary twist drill to be used for starting a hole.

Referring to the parts of the new boring bar which are shown in Fig. 3, it will be seen that *A* represents the bar, *B* the lock-nut for securing the bar in place, *C* the cutter which

Fig. 3. Parts of the Marvin & Casler Boring Bar

is made in various lengths to adapt the bar for a variety of classes of work; *D* the key which fits in the keyway in cutter *C*; and *E* a wedge which fits under the cutter. Both the key *D* and the cutter *C* are placed in the dovetail slot in the boring bar and secured in place by driving the wedge *E* under them. By this means, the cutter can be secured at any desired point along the bar. No adjustment of the cutter *C* is necessary as the depth of the cut is controlled by the adjusting screw in the head, which throws the bar the required distance off center. The application of this boring bar to the Marvin & Casler offset head, adapts the equipment for deep hole work.

GARVIN NO. 1-S DUPLEX DRILL

The illustrations show a horizontal duplex drill which has been placed on the market by the Garvin Machine Co., Spring and Varick Sts., New York City. The design of the machine has been worked out with the view of eliminating trouble from the chips interfering with the free sliding of the heads on the ways. Another feature of the design consists of the provision which has been made for adjusting each head to provide for the use of a short worn drill in one head and a long new drill in the opposite head. This arrangement affords a number of advantages in operating a machine of this type.

Where work is to be faced to shoulders—working from fixed points—either head can be adjusted with the nicety of snap gage work and as the tool is worn away by grinding, the adjustment allows the head to be reset to maintain the required dimensions.

Fig. 1 shows the machine and Figs. 2 and 3 show details of its construction. The ball handle rotates a nut which is released by an eccentric binder and reclamped after the necessary adjustments have been made. The heads are held to their bearings by taper gibs and are fed forward by a hardened screw which is cut right-hand at one end and left-hand at the other; the drive is effected through intermediate bevel gears from the power feed box. The worm-gear shaft is extended to receive the capstan shown in Fig. 1 and is provided with a handle for quick return. Fig. 2 shows a cross-section through the spindle, which is of special construction. Both front and rear bearings are of the taper type and in adjusting the spindle, the method of procedure is as follows: The nut lock *A* is loosened and the thrust screw *B* is then backed off, the nut *D* at the opposite end of the spindle also being loosened. The nut *E* is then tightened, drawing the front box and the spindle back to the rear bearing. After this has been done, the nut *D* is tightened and the nut *E* released until the spindle rotates freely when turned by the driving pulley. The thrust screw *B* is then screwed up until it just touches; the nut *C* is then jammed and the nut-lock *A* entered into the notched recess in the nut *E*.

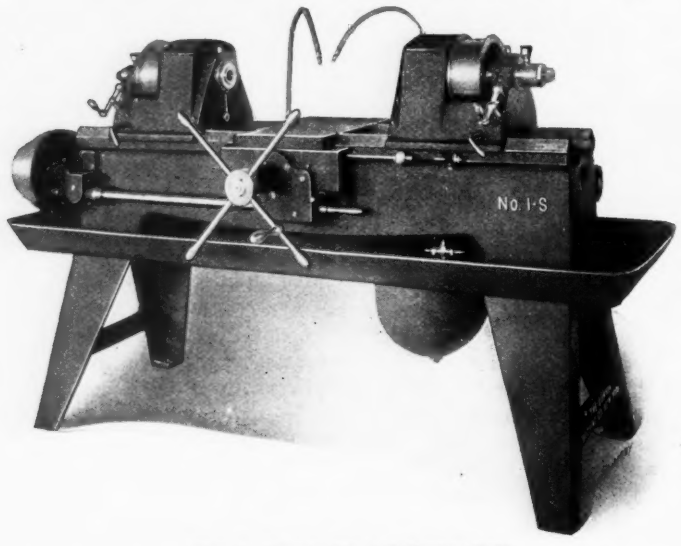


Fig. 1. Garvin No. 1-S Duplex Drill

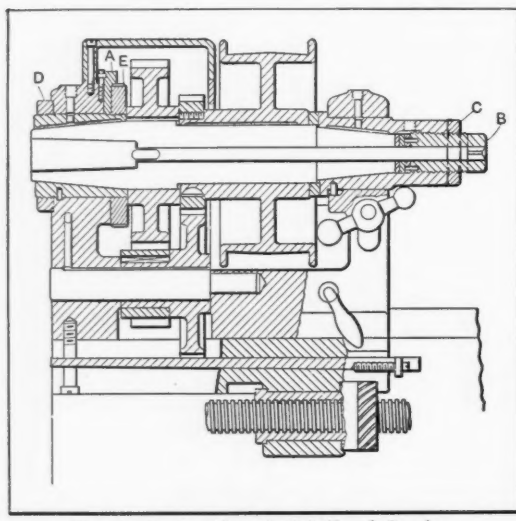


Fig. 2. Section through Spindle of Garvin Duplex Drill

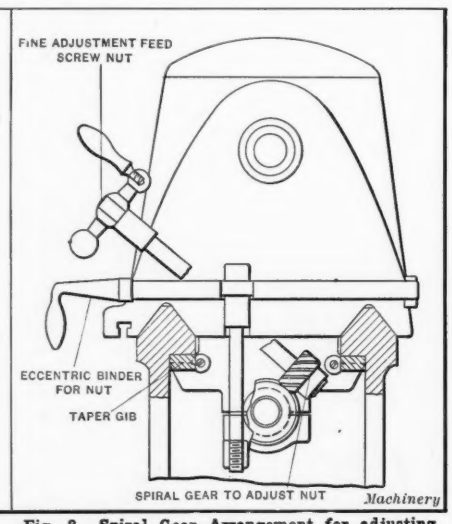


Fig. 3. Spiral Gear Arrangement for adjusting Binder Nut

It will be seen from the illustration that the back-gearing, which has a ratio of 3 to 1, is completely enclosed, thus affording protection for both the operator and the mechanism. The illustrations show a back-geared type of machine, but these machines are also made without back-gearing. The weight of the machine, including the countershaft, is about 2000 pounds.

WATSON-STILLMAN HYDRAULIC PIT JACK

The Watson-Stillman Co., 192 Fulton St., New York City, has recently made a change in the construction of its hydraulic pit jacks that has greatly improved these tools. The hand-operated pumps have been replaced by pumps driven by air engines that can be attached to any style or size of jack of this company's manufacture. The use of compressed air at about 90 pounds per square inch pressure has become so universal in roundhouses and railroad shops that the air-driven engine adapts itself admirably to modern shop equipment. To make the power connection, it is merely necessary to run a rubber hose or other flexible tubing from the shop air main to the pump engine, just as is done in the case of pneumatic riveters. The operating valves can be placed in any convenient position which will permit the foreman or man in charge to operate the lift in addition to directing the work of his men. The use of this air engine, therefore, eliminates one man—the pump operator—from the crew.

Fig. 1. Watson-Stillman Pit Jack with Ram down

To operate the machine, the straightway valve shown just over the air engine, is opened. This admits air on top of the water in the cistern, thus forcing the water into the ram cylinder and elevating the ram into the working position. The straightway valve is then closed and the globe valve shown at the extreme left is opened; this starts the engine, the function of which is to do the heavy lifting. To lower the ram—either loaded or unloaded—the relief valve shown near the center of the cistern is opened by means of the long lever. The arrangement of the valves is such that they are all within reach of the operator without requiring him to move. This machine is adapted for a track gage of 24 inches. The wheels are 14 inches in diameter and are carried by axles which run in ball bearings to eliminate starting friction. A side adjustment of 6 inches is provided; the distance from the track to the bottom of the cylinder is 1½ inch; and the distance from the pit track to the saddle with the ram down is 3 feet 4 inches. The telescopic ram does away with the necessity of a sub-pit cylinder. This jack has a lifting capacity of 15 tons and

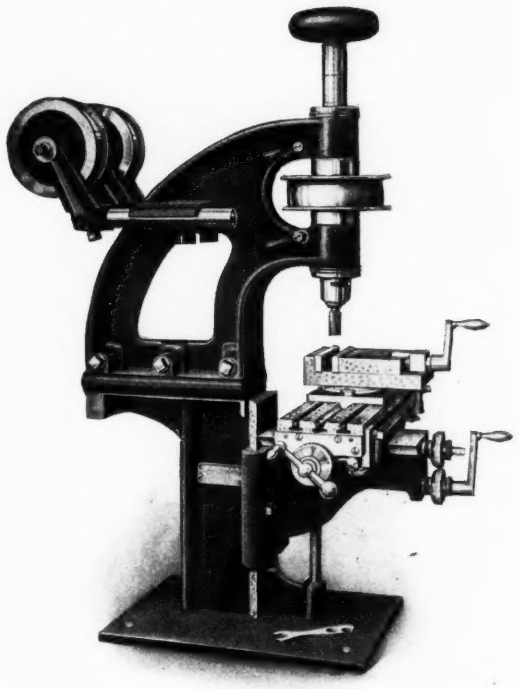
Fig. 2. Watson-Stillman Pit Jack with Ram extended

a total rise of 49½ inches. The telescopic ram is in two lengths of 3 and 4½ inches in diameter, respectively, and since it is equipped with an air power pump, it embodies the latest feature in these tools.

As most railroad men know, pit jacks are used for replacing wheels and axles on cars and locomotives. They are placed on a narrow gage track in a pit below and perpendicular to the main track. The ram rises, catches the axle in a saddle mounted on its end, and lowers it clear of the chassis; then carries it to an out-of-the-way position at one side of the main tracks. This same type of jack is used for removing and replacing heavy motors used on electric railway cars.

HARDINGE VERTICAL BENCH MILLING MACHINE

The bench milling machine illustrated herewith is a recent product of Hardinge Bros., Inc., 3133-3141 Lincoln Ave., Chicago, Ill. It will be seen that this machine is designed along the lines of a regular plain milling machine, the table being raised or lowered through miter gears operated at the end of the knee.



Hardinge Vertical Bench Milling Machine

This machine is adapted for using the Cataract No. 3 draw-in chucks. The advantage of this lies in the fact that a shop using No. 3 bench lathes can use the same chucks in either their lathes or milling machines. The use of draw-in chucks on this machine is particularly convenient in that it enables small cutters with straight shanks to be used. This machine is especially suitable for small die work and similar classes of milling.

ROCHESTER TABLE FOR BORING, MILLING, DRILLING AND TAPPING MACHINES

The universal table illustrated in this connection has been placed on the market by the Rochester Boring Machine Co., Rochester, N. Y., for use on the floor type of boring, milling, drilling and tapping machines of this company's manufacture. This table is universal in operation, having a rotary movement of 360 degrees and a tilting movement of 90 degrees, so that various machining operations may be performed on both the sides and top of the work and at any angle, without requiring re-setting. This results in a material saving of time, as well as in increased accuracy of the product by doing away with the necessity of resetting the work. It is generally easier and quicker to change the cutters or other tools than to reset the work.

The table is of box type construction, braced and cross-ribbed to give the necessary rigidity. It can be traversed to and from the column by a ratchet operating a pinion that engages with a rack in the floor plate. When traversed, the table is guided by a tongue engaging with a groove in the floor plate, thus providing for having the movement of the table parallel to the spindle. The rotary movement is obtained by a worm which runs in an oil bath and engages a worm-wheel of large diameter and coarse pitch. The table is elevated by a worm engaging with a worm-wheel connected

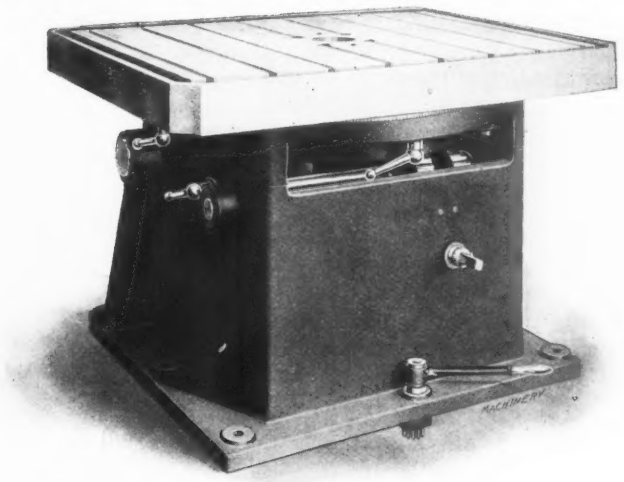


Fig. 1. Rochester Universal Table for Floor Type Boring, Drilling, Tapping and Milling Machine

to the pinion which is cut from the same piece as the shaft; this pinion meshes with the elevating gear.

Graduations are provided reading in degrees, and with the micrometer dial, readings can be obtained to 1/12 degree. The dials are also arranged with adjustable zero indicators. One turn of the crank rotates the table through 10 degrees, and the table is elevated through one degree for one turn of

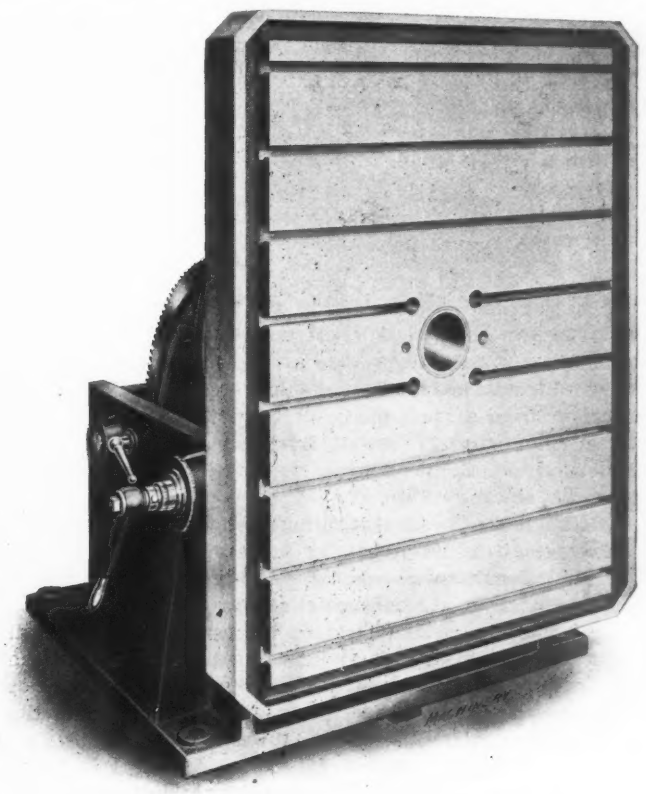


Fig. 2. Rochester Universal Table tilted to an Angle of nearly 90 Degrees

the elevating crank. A hole 4½ inches in diameter—containing a bushing—is provided at the center of the table to allow boring bars to be passed through. A locking device is furnished for clamping the bushing. This table can be quickly clamped in any position—either tilting or rotating, and at any angle.

LANGELIER HOT SWAGING MACHINE WITH HEATING FURNACE

The swaging machine provided with a special holder and furnace shown in Figs. 1 and 2 was designed and built by the Langelier Mfg. Co., Providence, R. I., for swaging spinning spindles, straight and taper shank twist drill blanks, taper reamers, end mills, live axles for autos, round file blanks and many similar pieces that are customarily turned on screw machines or forged and ground. A large saving of stock can be effected by this method over other processes where metal is removed in reducing the profile of the piece, as there is absolutely no cutting away of the metal in swaging. In making high-speed steel drills and end mills, the saving of expense is considerable. In addition to this saving and the improvement which takes place in the stock as it is compressed, the machine swages the blanks so close to size that in most cases only a few thousandths have to be ground off to finish the piece completely.

The service required of this machine is particularly severe because the stock is fed into it at a forging heat, and to handle the work with ample reserve of power, the entire unit has been ruggedly constructed. The unit consists of an exceptionally heavy swager, a rack and pinion driven feed mechanism with pneumatic chucks, and a continuous rotary gas heating furnace. The swager head is cored out around the circumference and at the back to provide a chamber with wide ports through which a constant flow of cold water—either from city pressure or from a small pump—is maintained while the machine is running to prevent it from heating up. This construction enables the machine to be kept in continuous operation on hot stock, avoiding the necessity of shut-downs to cool it off. Simple means of controlling the inflow of water and the drainage of the head chamber are provided.

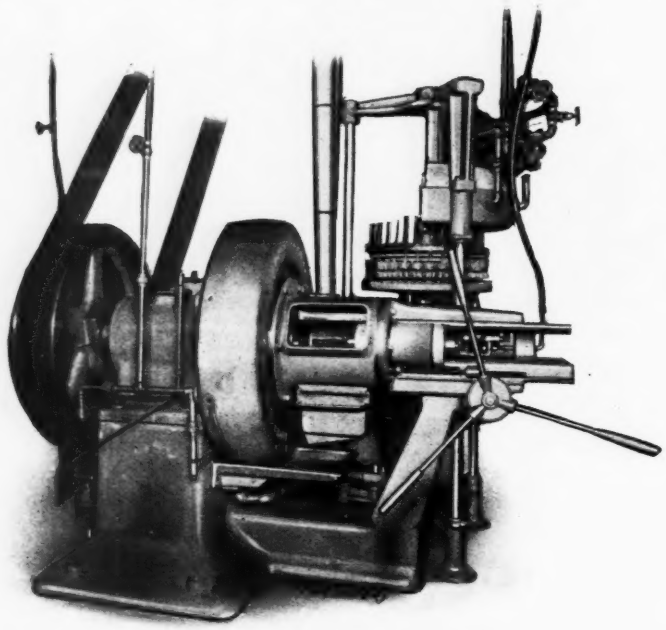


Fig. 1. Front View of Langelier Hot Swaging Machine

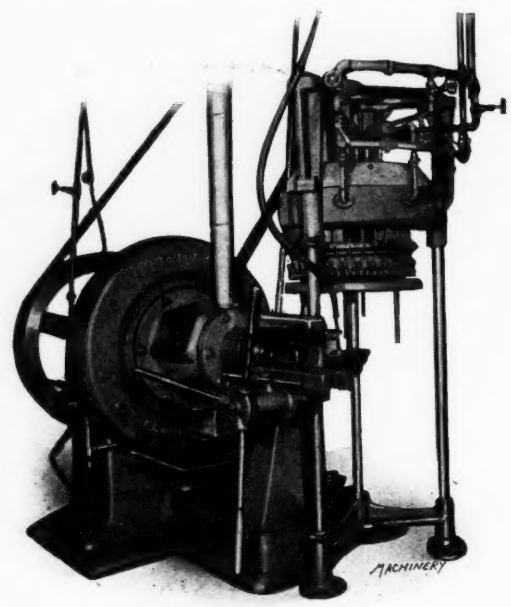


Fig. 2. Side View of Swaging Machine showing the Heating Furnace

The vital element of the machine—the spindle—is made of hammered steel, turned and ground to size, bored throughout its length and slotted diametrically across the enlarged head end. A circular steel ring, tongued and screwed into the spindle greatly strengthens this open end. All sides of the slot are lined with hardened steel plates that are riveted to the spindle. This construction practically encloses the dies and hammer-blocks in a hardened steel box and insures long life for the surfaces in contact. Surrounding the head of the spindle is a circular cage containing ten hardened steel rolls, the rolls being located equidistant from each other and kept in their relative positions by the cage lands. The cage is fitted freely into a heavy hardened steel ring that is accurately ground and forced into the head under heavy pressure. As a further precaution to prevent this ring from working loose from the continual hammering it receives, four cap-screws with washers bind it firmly to its seat. The cage is reinforced on both ends by circular steel plates, and is of as light design as is consistent with strength. To control the opening of the dies, two conical pointed screws are screwed into the front plate on the slotted end of the spindle and project into a corresponding hole in the end of the hammer-blocks just the amount necessary to give the required die opening. Washers of the required thickness are used under the heads of these screws to regulate the distance the conical points of the screws enter the hammer-blocks.

The spindle runs in loose, cast-iron bushings which creep slowly around with it, giving about 50 per cent more bearing surface. This makes it possible and inexpensive to replace the bushings when they are worn out, without requiring the entire head of the machine to be sent to the factory, as would be the case with stationary bushings or if the spindle revolved directly in the bearing in the machine head. The full power of the heavy flywheel is exerted on the dies and work through the spindle, which explains the ease and rapidity with which the machine produces considerable reductions and brings the work accurately to size. The circular opening through the spindle back of the dies permits pieces with a long parallel portion to pass beyond the dies, and serves as a duct to admit a blast of compressed air on the dies to keep them running cool. This arrangement also makes it possible to blow the scale out of the dies into a collecting receptacle, especially provided in the holder. A special connection is provided at the extreme end of the spindle for leading the air blast into the spindle.

The flywheel is 38 inches in diameter, with a rim 7½ inches thick, and carries a 7-inch belt. The hub of the wheel is split, and is clamped to the spindle with two ⅞-inch bolts; it is also keyed to the spindle. This arrangement has been found very effective in preventing the wheel from working loose. A clamping nut is provided on the rear of the spindle, that serves both as a means of taking up end play in the spindle and holding the flywheel in position. A large oil reservoir, immediately back of the machine, serves to collect the oil which is maintained in circulation through the automatic oil feed pump driven from the main spindle of the machine; the oil cools somewhat before being repumped to the working parts of the machine.

The holder is a one-piece steel casting of tubular design, bored out through its entire length to provide practically a perfect bearing for the holder piston. This piston, which carries the chucks for gripping the work, feeds the work into the dies and withdraws it through a steel pinion which meshes with a rack underneath the piston slide, the movement being operated by the capstan wheel shown in the illustrations. The piston and rack have stub form teeth to obtain the greatest possible strength and to resist the sudden shocks which attend swaging. The chucks are of the self-centering. spring type;

they are interchangeable, and are tightened and released by compressed air. When the holder piston reaches its rearmost position, it automatically shuts off the air pressure, thus opening the jaws of the chuck so that the blank to be swaged may be readily inserted or the swaged piece withdrawn from the chuck. As it leaves this position for the feeding stroke, the air valve opens, letting the full air pressure bind the chuck on the work. This form of chuck is very rapid in operation and requires almost no attention at all from the operator. A "mouth" is cast in the side of the holder to provide ready access to the chucks. This facilitates the insertion of blanks and the removal of swaged pieces, as well as allowing access to the dies of the machine for changing them.

The exact distance that the swaging takes place upon the stock may be easily adjusted to suit conditions. No further attention is then required from the operator until this setting is again changed. The fumes emitted by the burning of some of the lubricating oil which flows into the dies, are prevented from escaping into the room where the machine is installed by a small fume exhauster which is fastened to the ceiling. This exhauster carries the fumes outside the building. The holder is a vital part of the machine, and it has been designed with exceptional strength to absorb the recoil of the pieces from the dies as well as to make the machine easily operated by unskilled help. As a part of the unit, a continuous rotary gas heating furnace has been designed for heating the blanks to the proper temperature required for the stock that is being swaged.

Several changes of heating and feeding speeds are provided through crown gears, which permit of accelerating or retarding the speed in accordance with variations in the diameter and character of the stock, and the length to which it is to be heated, thus avoiding all loss of time between swaging passes. The furnace is made in two types, one for heating carbon steel and the other with more burners and with many modifications for heating high-speed steel. The proper temperature can be closely gaged by regulating the air and gas supply through suitable valves. About half of the dial may serve as loading stations while on the other half the pieces are being subjected to the heating blasts from the burners. Special fire-brick forms are used which almost entirely enclose the blanks, preventing any waste of heat. The exact length and time of heating may be closely gaged, and pieces of different lengths may be heated in the same furnaces by a suitable elevating and lowering dial on which the pieces rest. The dial is kept in motion through pulleys at the base of the furnace, belted from the main countershaft overhead. The machine weighs approximately 11,000 pounds including the holder, and the flywheel runs at from 250 to 280 R.P.M. The floor space occupied is 8 feet by 5 feet.

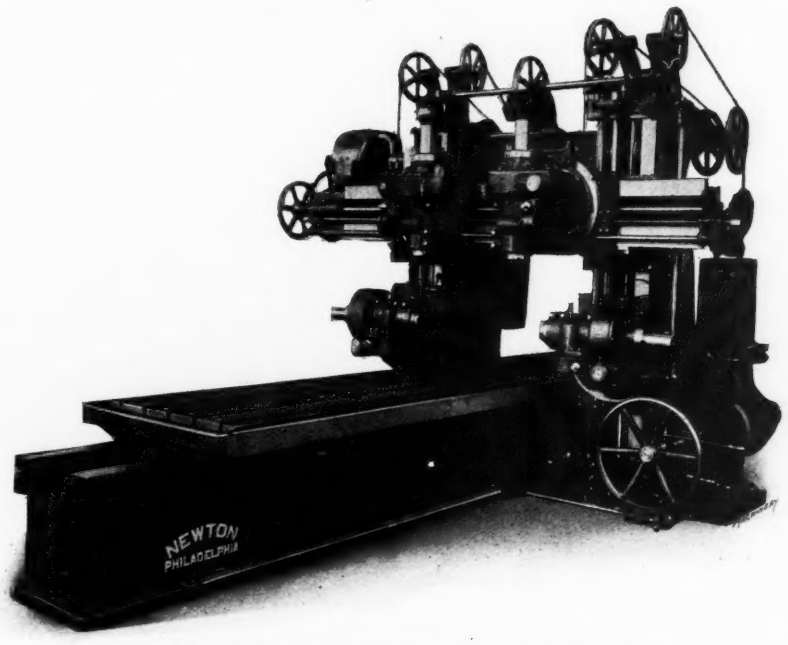


Fig. 2. Right-hand Side of Newton Multiple Spindle Milling Machine

NEWTON MULTIPLE-SPINDLE MILLING MACHINE

A motor-driven four-spindle milling machine which has been added to the line of the Newton Machine Tool Works, Inc., 24th and Vine Sts., Philadelphia, Pa., is illustrated in Figs. 1, 2 and 3. This machine is equipped with two motors. The motor mounted on the floor drives the two side heads—each of which is independently clutched—and also controls the fast power traverse, the feed of the table, and the cross feed of the vertical spindles on the rail. The drive for the vertical spindles is provided by the motor which will be seen mounted on the rail. This arrangement permits of a wide speed variation for the vertical spindles without introducing mechanical complications. Each of the heads is of the same dimensions and design.

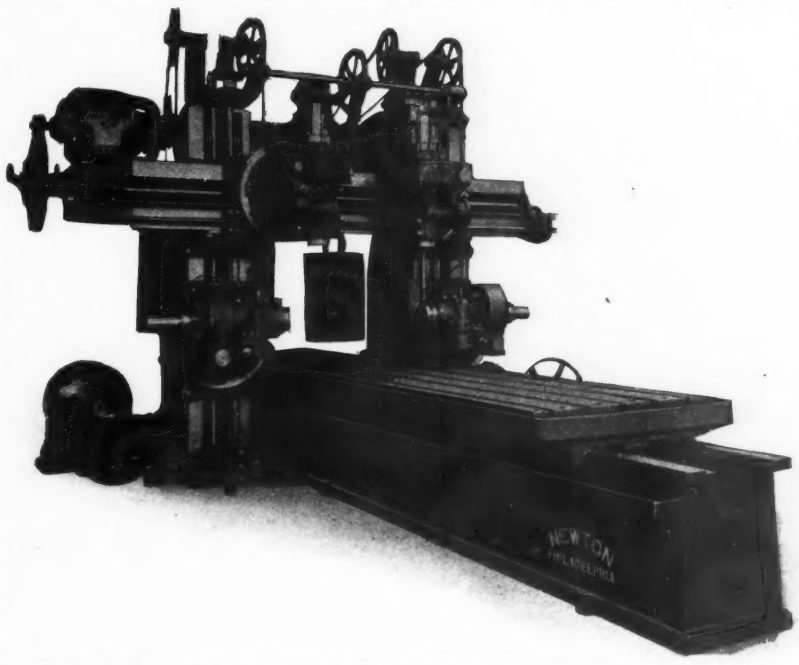


Fig. 1. Left-hand Side of Newton Multiple Spindle Milling Machine showing Motor Drive

The drive is taken from vertical spline shafts through bevel and spur gears which transmit the power to a steel worm which engages with a bronze worm-wheel. The worm and worm-wheel are both encased and kept flooded with oil. The diameter of the spindle is 4 inches and there is a straight and taper bronze bushed bearing in the sleeve, the largest diameter of which is 6½ inches. The spindles are arranged to drive the cutters by means of a broad faced slot, and the cutters are held in place by means of a retaining bolt. Adjusting screws provide for adjusting the spindle sleeves and each of the spindles may be swiveled through 45 degrees by means of a worm and worm-wheel arrangement which is clearly shown in the illustrations. In the end view, Fig. 3, the spindles are shown set at an angle.

The motor equipment of this milling machine is best shown in Fig. 1. It has already been stated that the motor mounted on the floor is used to drive the side heads and to provide for the feed of the table and the traverse of the vertical heads. Power is transmitted to both of the side heads by a single horizontal shaft, and the drive for each of the side heads is clutched by means of the hand levers shown near the floor at each side of the machine. Each side head is counterweighted

and provided with means for vertical elevation by hand; the left-hand head may be attached to the finished base of the cross-rail, as shown in Fig. 1, to provide for power elevation. The right-hand head has a fast reversing power elevation and the work table is provided with nine changes of geared feed with reversing fast power traverse and hand adjustment. The cross-rail is independently counterweighted and is provided with power elevation through the motor on the rail, which was previously referred to. Each of the vertical heads is provided with hand adjustment in addition to the reversing feed and fast power traverse across the rail. The motion is transmitted through the gear-box mechanism that controls the table movement.

The principal dimensions of the machine are as follows: Size of working surface of table, 16 feet long by 42 inches wide; minimum distance between ends of horizontal spindles, 16 inches; maximum distance between ends of horizontal spindles, 48 inches; and maximum height from table to under side of vertical spindles, 36 inches.

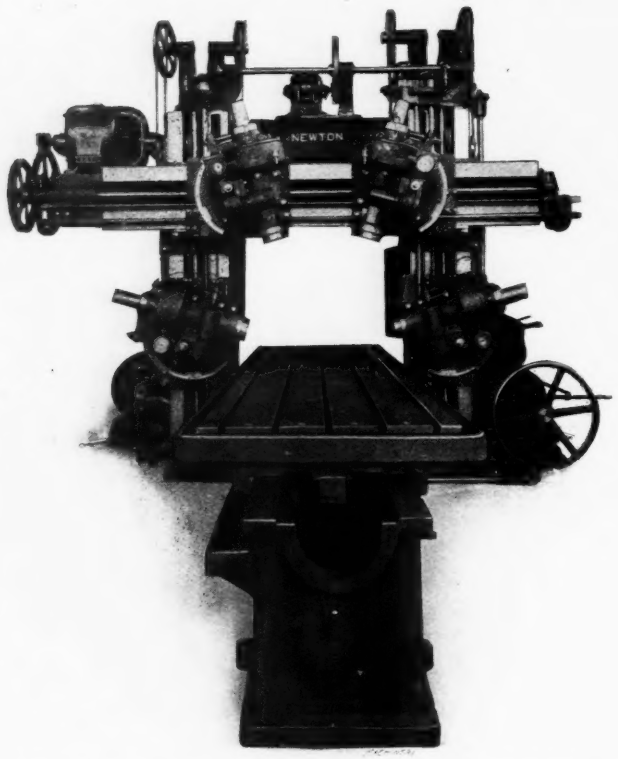
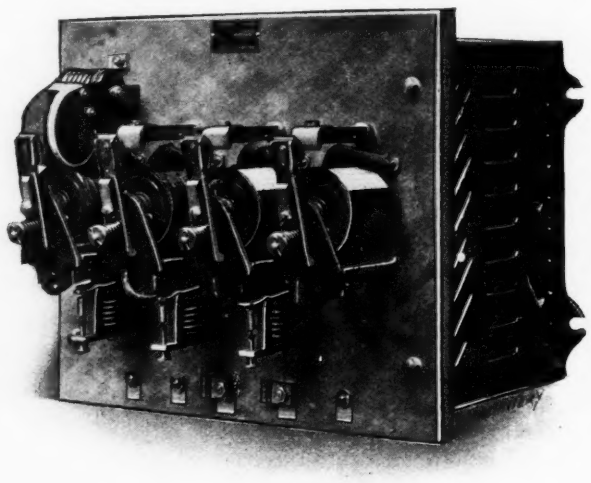


Fig. 3. End View of Newton Milling Machine with Heads set at an Angle

CUTLER-HAMMER MOTOR CONTROLLER

The present-day tendency in manufacturing is to offer the workman every opportunity to specialize in the work for which he has been trained. With this object in view, the design of manufacturing equipment is being worked out with a view of relieving the workman as far as possible from routine duties, so that he may concentrate upon work which requires the attention of the skilled mechanic. This means a high-grade product and increased production. Among such devices for relieving the workman of responsibility, automatic control of motor-driven machine tools is an important item, and the accompanying illustration shows a new type of automatic series-relay motor controller for motor-driven machine tools, which has been placed upon the market by the Cutler-Hammer Mfg. Co., Milwaukee, Wis. With a machine equipped with one of these controllers, all that the workman is required to do is to throw in the switch—regardless of whether the load is light or heavy, at the time of starting—and the motor will be automatically brought to the required operating speed without an undesirable inrush of current or other trouble. Proper acceleration is assured, time is saved and damage to the motor or machine, due to possible carelessness on the part of the operator, is avoided.

With this class of controller, the resistance is cut out of the circuit, and the motor accelerated automatically. The magnetic switches close in succession, the speed of closing successive switches depending upon the motor current which acts through the relays to close the switches or hold them open. These relays are positive in action and respond to the variations in motor load, so that when the motor is started under light load, it is accelerated more quickly than if it is heavily loaded. In the latter case, the switches are not closed so quickly as a result of which, the resistance



Cutler-Hammer Automatic Controller for Motor-driven Machine Tools

is left in the main circuit for a longer time and prevents the current from exceeding a predetermined maximum value. A smaller controller of this type is made in capacities up to 15 horsepower for use on 110, 220 and 500 volt circuits. Another type of heavy main-line magnetic switch is made in larger capacities. With this form of motor control, the automatic controller can be placed out of reach, which is desirable in some cases.

DAVIS-BOURNONVILLE MECHANICALLY-GUIDED METAL-CUTTING TORCHES

A recent addition to the line of apparatus developed by the Davis-Bournonville Co., 30 Church St., New York City, for mechanically guiding cutting apparatus, is shown in Figs. 1 and 2 of the accompanying illustrations. This new machine is known as the "radiagraph." It is a motor-driven device especially adapted to straight or circular cutting. The construction

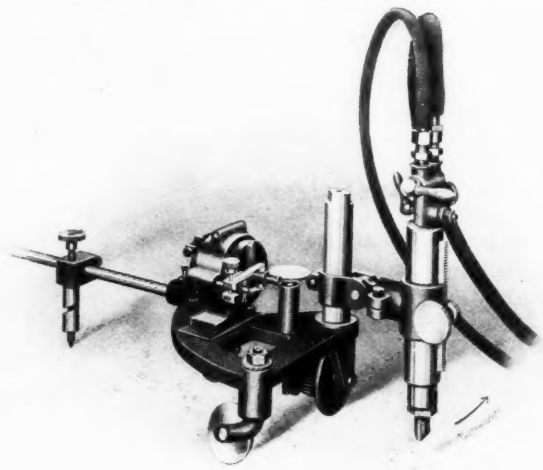


Fig. 1. Davis-Bournonville Radiagraph for Straight or Circular Cutting

is very simple, the principal parts of the machine being a three-wheeled carriage for supporting the cutting torch, which is propelled along the surface of the work at the most efficient rate of speed by a small motor.

As will be seen by referring to Fig. 1, this motor connects with a vertical shaft through worm-gearing. At the lower end of this vertical shaft, there is a second set of worm-gearing which transmits motion to a horizontal shaft, which, in turn, drives the front tractor wheels through spur gearing. When

it is desired to cut a circular opening, the conical center seen to the left is turned down into engagement with the surface of the work, which lifts the carriage slightly so that the weight is supported by the two outer wheels. The motor is started and the carriage then moves in a circle about the central pivot, and an opening is cut by the torch, the diameter of which depends, of course, upon the distance from the torch tip

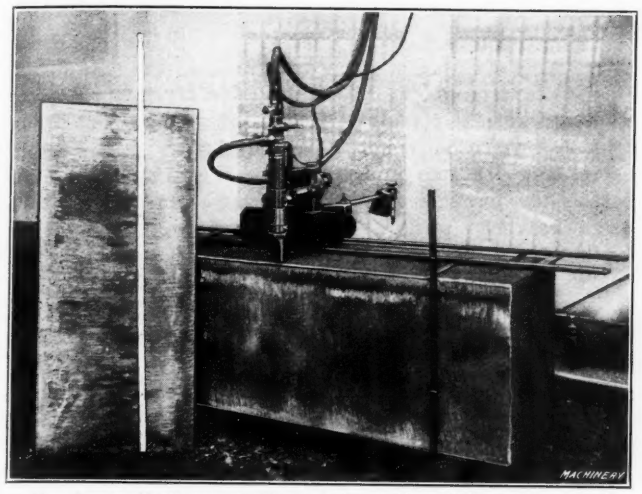


Fig. 2. Application of Radiagraph for cutting 16-inch Armor Plate

to the central pivot. The machine has a capacity for holes six inches in diameter and upwards. The driving motor is equipped with a small friction brake for regulating the speed in accordance with the thickness of the metal being cut. The

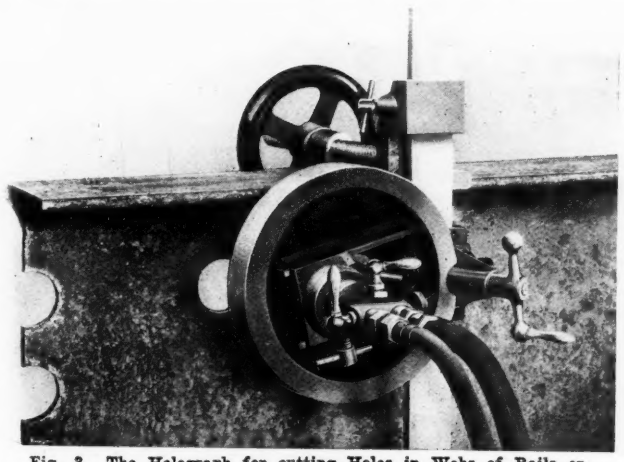


Fig. 3. The Holograph for cutting Holes in Webs of Rails or Structural Parts

rate of speed is shown by an indicator, not in place in this particular view.

Fig. 2 shows the application of the radiagraph to straight cutting, the work in this instance being a piece of armor plate 16 inches thick. The machine is caused to move in a straight line by mounting it upon parallel tracks having V-shaped grooves for the wheels. This track is notched at the ends so that two sections can be joined readily. For ordinary work one section is sufficient, but when taking long cuts, two sections are employed, thus making it possible to prolong the cut indefinitely by placing the rear section to the front as soon as the machine has passed it. The rate of traverse for cutting 16-inch armor plate is about four inches per minute and, as the illustration shows, the kerf left by the flame is remarkably smooth, considering the depth of the cut. For this particular work, the oxygen pressure was 125 pounds per square inch. In case it is not convenient to connect the motor with a lighting circuit, small batteries can be used, so that the machine is adapted for yard use as well as in the factory.

Another recent development of the Davis-Bournonville Co. is shown in Fig. 3. This machine is known as a holograph and it was designed for cutting holes in the webs of rails or in structural material not more than ¾ inch thick. This machine has a circular member for holding the torch, which is rotated through bevel gearing by the handle seen to the right, thus causing the torch tip to move in a circle. The web of a rail can be pierced without any previous drilling and the machine will cut smooth round holes varying from ½ to 2 inches in diameter, in from 30 to 60 seconds. The diameter of the hole cut, is varied by simply shifting the torch holder to or from the center of the rotating disk. The torch rotating mechanism is held in position by a vertical bar which, in turn, is clamped to the rail by the screw or handle shown. The holograph is especially adapted for railroad work and for enlarging or cutting holes in structural steel.

BIGNALL & KEELER PIPE THREAD GAGE

A detailed drawing showing the parts of a new pipe thread length gage which has been brought out by the Bignall & Keeler Mfg. Co., Edwardsville, Ill., is shown in Fig. 2. Fig. 1 shows one of the machines of this company's manufacture equipped with this type of thread gage. Referring to the details of the gage shown in Fig. 2, *A* is a scale which is bolted to the carriage of the pipe threading machine. It will be seen

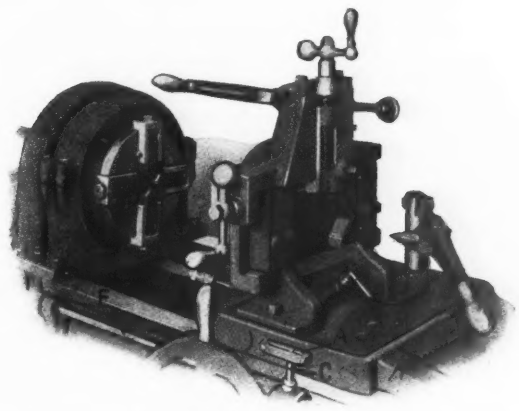


Fig. 1. Bignall & Keeler Pipe Threading Machine equipped with Length Gage

that this scale has a slot which is covered by the plate *B*. The pointer *C* is carried by the member *D* which is clamped to the rod *E*. This rod *E* is secured to the machine by means of two brackets. *F*.

When the carriage is moved, the indicating finger remains stationary until it comes into contact with the end of the slot in the scale member *A*. In operating a machine equipped with this gage, the carriage is run forward until the dies touch the end of the pipe; the indicating finger is then pushed along the rod *E* until it comes up against the forward end of

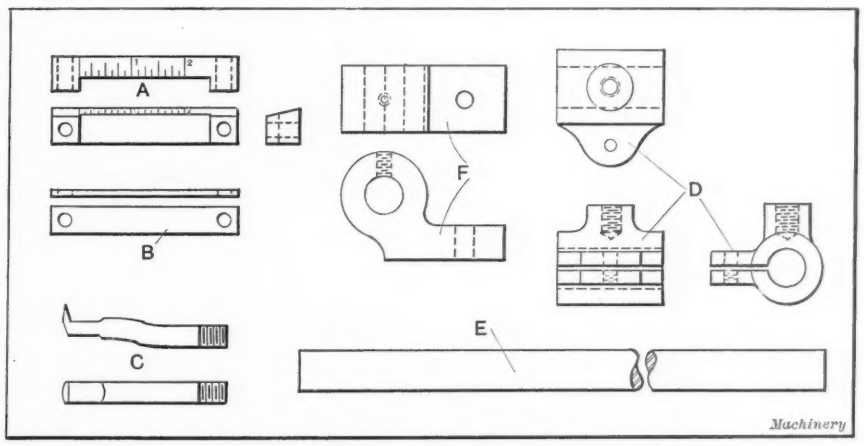


Fig. 2. Details of Bignall & Keeler Pipe Thread Length Gage

the scale. This brings the indicator opposite the zero mark. The indicating finger then remains stationary while the carriage and scale travel past it. When the desired length of thread has been cut, as indicated by the position of the pointer

over the scale, the machine is stopped. The scale is graduated in eighths of an inch and its face is set at an angle of 15 degrees with the horizontal, to make it easily read. All of the "P. D. Q. C." and "Peerless" 2 and 3 inch pipe threading machines of this company's manufacture are now being equipped with gages of this kind.

NIAGARA DOUBLE-SEAMING MACHINE

A double-seaming machine for use in the manufacture of cylindrical metal packages, which has been placed upon the market by the Niagara Machine & Tool Works, Buffalo, N. Y.,

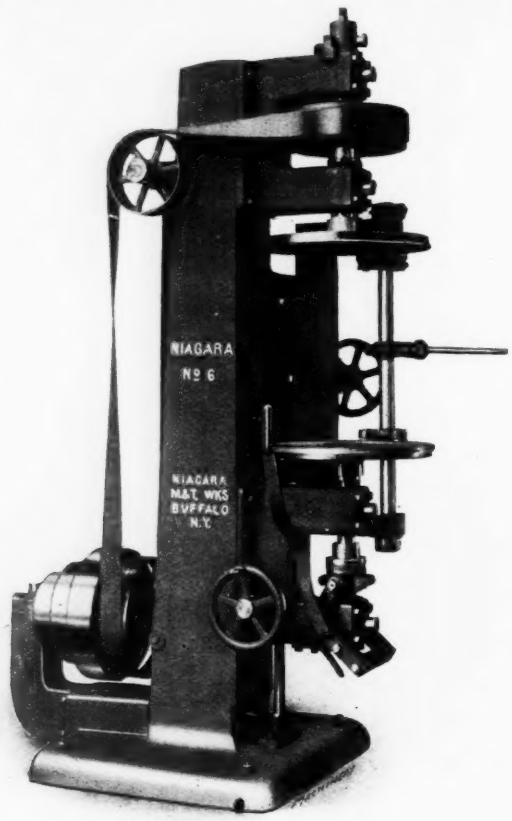


Fig. 1. Niagara Double-seaming Machine

is illustrated in Fig. 1. This machine is designed for comparatively large sized work, such as oil and asphalt barrels, garbage cans, ash cans, etc. It will handle work up to 26 inches in diameter by 36 inches in height, in material up to No. 24 gage soft steel. The machine will double-seam two ends of a drum or barrel at the same time, or double-seam one end and lay over the other edge of the body simultaneously, as shown in positions *B* and *C*, of Fig. 2. The heads and body of the work must be previously prepared, as shown at *A*, in this diagram.

The frame of this machine is of box-section. The upper spindle is mounted in stationary bearings, while the lower

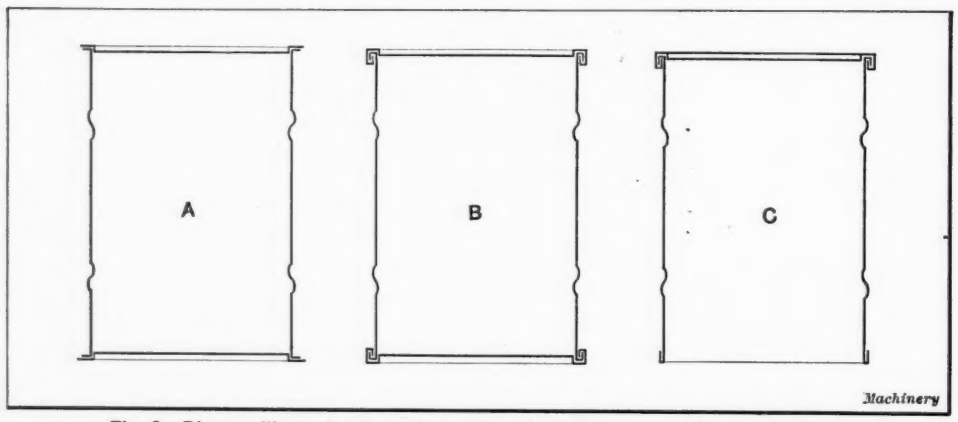


Fig. 2. Diagram illustrating Operations performed on Niagara Double-seaming Machine

spindle is adjustable vertically by means of a screw and hand-wheel. This enables the machine to be regulated to adapt it for different heights of work. The vertical chuck spindles are carried in ball-thrust bearings. The barrel to be seamed is clamped between the two chucks by means of a lever on the left-hand side of the machine. The seaming roll levers are mounted on a vertical shaft at the right of the machine and are made adjustable to suit the height of the work. The machine is arranged for three different speeds to permit running faster on small work, and slower on large work. As this machine operates on both ends of the work simultaneously, a greatly increased production is secured.

STOCKBRIDGE TWENTY-INCH SHAPER

The Stockbridge Machine Co., Worcester, Mass., has brought out a 20-inch cone-drive, back-geared shaper which combines several new features in its design. Most important among these is the arrangement of the cross-feed mechanism. This design has been worked out in such a way that it is impossible for a shiftless mechanic to operate his machine so that it takes the feed against the cut. Fig. 1 shows the new shaper; Fig. 2 gives a cross-sectional view of the cone pulley; and Fig. 3 shows the design of the cross-feed mechanism.

Referring to Figs. 1 and 3, the design of the cross-feed mechanism may be briefly described as follows: The two rods which actuate the feed are shown in Fig. 1, where it

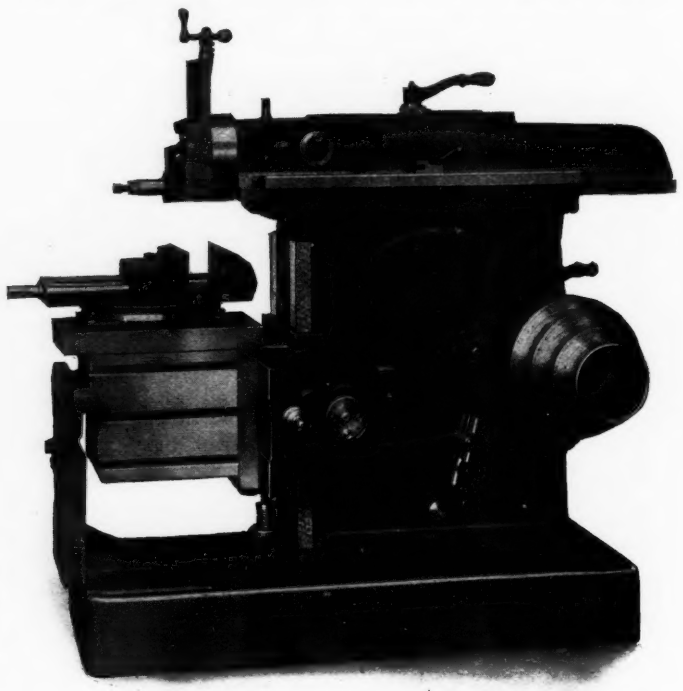


Fig. 1. Stockbridge 20-inch Shaper with Improved Feed Mechanism

will be seen that an adjustment is provided for regulating the feed which the machine takes at each stroke, the range being from zero up to ¼ inch. These rods lead over to the feed mechanism, which is clearly shown in Fig. 1, and also in more detail in Fig. 3. The feed rods actuate a feed pawl *A* which engages with ratchet teeth on the inside of gear *B*. The number of teeth which are "picked" at each stroke of the ram is regulated by the adjusting screw, previously referred to. The feed-screw *C* carries a pinion *D* and motion is transmitted to the feed-screw from gear *B*, either directly through gear *E* or indirectly through gears *E* and *F* to gear *D*. The small lever *H* controls the method of driving to give the feed in the required direction. With the lever in the position shown in Fig. 3, it will be seen that the gear *E* is in mesh with gear *D*. If the lever *H* is thrown over to the opposite position, the rocker member *G*, which carries the gears, is lifted in such a way that the gear *E* is thrown out of

mesh with gear *D* and drives through the gear *F* which is brought into mesh with gear *D*. With this mechanism it is only possible for the machine to take the cross-feed on the return or idle stroke. If it is desired to feed by hand, the power feed can be disengaged by lifting the pawl *A* into the neutral position, where it does not engage with the teeth of the ratchet wheel.

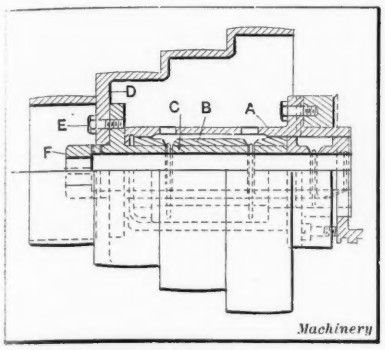


Fig. 2. Cross-sectional View of Cone Pulley of Stockbridge Shaper

Fig. 2 shows a cross-sectional view of the cone pulley on the drive shaft. It will be seen from this illustration that the shaft is supported by a type of cone bearing which relieves it from practically all of the belt pull. The bearings are of the ring oiling type, the construction being clearly shown. Referring to the illustration, the cone bearing *A* is bolted to the column of the machine and the bushing *B* slips into the bearing. The cone hub *C* fits inside the bushing and the cone *D* is bolted to the cone hub by means of four bolts *E*. The two-jaw clutch *F* engages with the clutch on the cone hub, the clutch being keyed to the driving shaft.

The table construction is similar to that of the standard construction which has been adopted by this company. The table is mounted on the knee and overhangs the saddle in such a way that part of the pressure is taken on the saddle. When the machine is to be used for larger work, it is also possible to supply larger tables. The crank motion is of the familiar two-piece crank type used by the Stockbridge Machine Co., and the main bearing is ring-oiled.

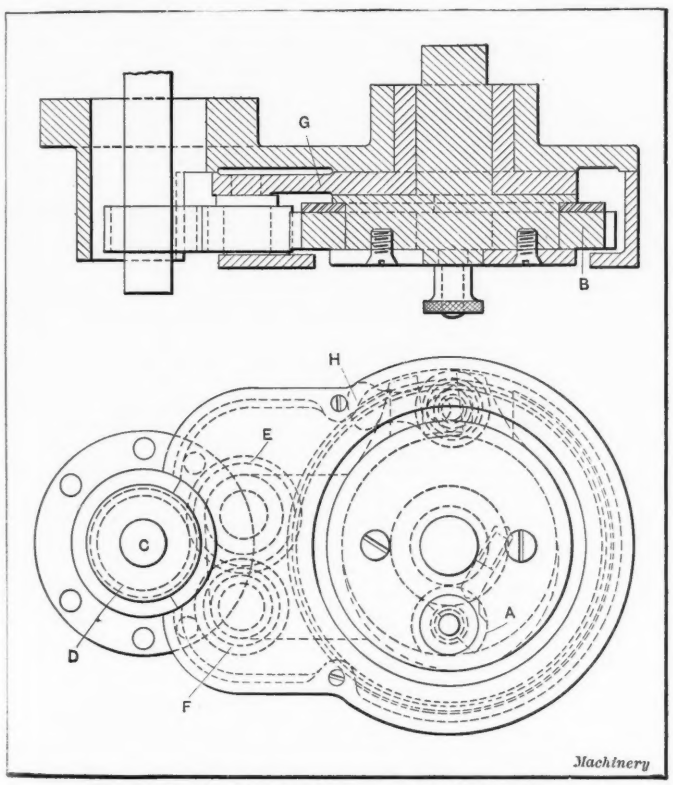


Fig. 3. Detail of Feed Mechanism of Stockbridge Shaper

DODGE CAPILLARY BEARING

A form of self-oiling bearing in which the oil is lifted from the reservoir by capillary attraction has been placed upon the market by the Dodge Mfg. Co., Mishawaka, Ind. Fig. 1 shows a sectional view of the bearing. Referring to this illustration, it will be seen that there is an opening at the bottom of the bearing, and a wooden block—the lower part of which dips into the oil—is held against the shaft by a spring. A top view of this block is shown at the left-hand side of Fig. 3. It will be seen from this illustration that a series of slots is sawed in this block, these slots coming to a sharp angle at one end. The tendency of the oil to rise, due to capillary action, is dependent upon the distance between the surfaces. As a result, the oil rises highest in the narrow portion of the slots and comes in contact with the shaft over these points. A constant film of oil is maintained on the shaft in this way,

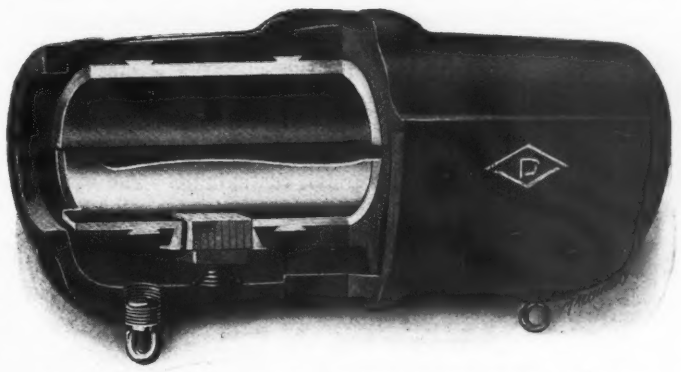


Fig. 1. Sectional View of Dodge Capillary Bearing showing Oil Grooves

and oil grooves are cut in the sides of the bearing, as shown in Fig. 1, these grooves being kept full of oil which is carried up by the shaft. The right-hand illustration in Fig 3 shows the way in which the oil is carried up in the narrow ends of the slots in the wooden block, the shaded and dotted sections showing the oil in the narrow ends of the slots at each side of the block.

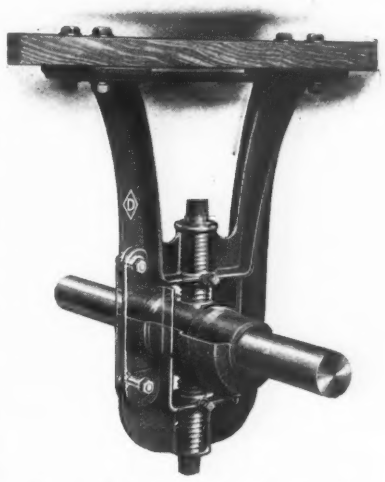


Fig. 2. Dodge Hanger equipped with Capillary Bearing

As there is no mechanical agitation of the oil in the reservoir, any foreign matter which is present in the oil is allowed to settle to the bottom. As a result, only pure oil is admitted to the bearing and there is no trouble due to friction and wear caused by admitting gritty matter into the bearing. The reservoir has a capacity for enough oil to last the bearing for about six months, and with the exception of an inspection at intervals of about three months, the only attention which the bearing requires is to be cleaned and refilled twice a year. Bearings of this type are applied to the various forms of hangers made by the Dodge Mfg. Co. Fig. 2 shows a hanger provided with one of these bearings, and by referring to this illustration it will be seen that the provision of adjusting screws enables the alignment on the shafting to be accurately regulated.

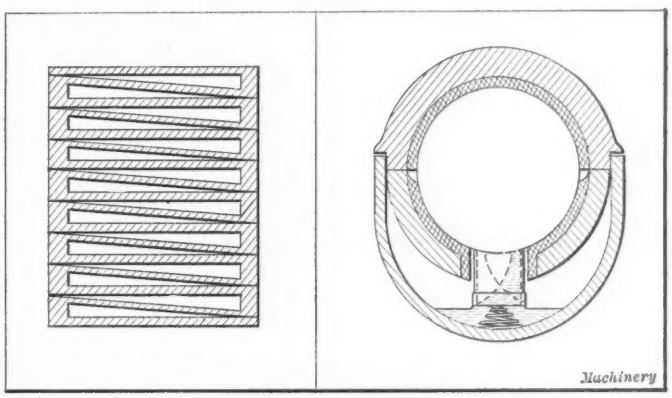


Fig. 3. Top View of Block and Diagram illustrating Rise of the Oil

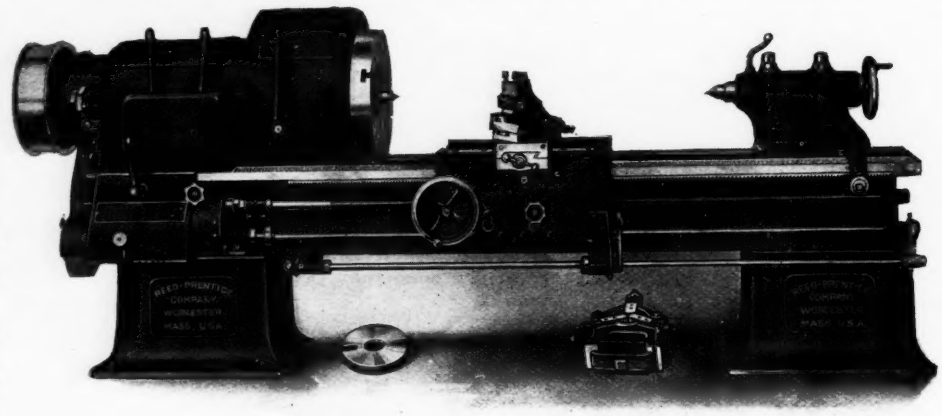
REED 20-INCH GEARED-HEAD LATHE

The 20-inch geared-head lathe illustrated herewith is a recent product of the Reed-Prentice Co., Worcester, Mass.

This machine is of the heavy-duty type, and is provided with thirteen gears in the headstock which give eighteen changes of spindle speed ranging from 7 to 533 revolutions per minute. All of the speeds are selective, and any speed can be obtained almost instantly, the changes being made while the machine is running. As the gears are always in mesh, it is impossible to damage them in making changes, and a suitable friction clutch is provided, which takes up any shock. The control of the lathe spindle is provided by a lever at the right-hand side of the apron; this lever travels with the apron and is within easy reach of the operator. The spindle reversing mechanism in the head consists of spur gears and a double friction clutch. These gears are not used to drive the lathe, being merely intended for reversing the spindle. The control is very sensitive, enabling the operator to start, stop or reverse the spindle almost instantly. To secure a given spindle speed, it is merely necessary to set a lever opposite the required speed on the index-plate. The changes of feed are also obtained by a simple lever movement. The ease with which these changes are made will insure having the operator run his machine under the most favorable conditions of speed and feed for the work on which it is engaged.

It will be seen that this lathe is equipped with a single-pulley drive, the pulley being of large diameter and wide face, so that ample power is provided to utilize the full capacity of high-speed steel. Ball bearings support the driving pulley, thus saving a considerable amount of power. The pulley runs at 400 revolutions per minute and provides a constant amount of power at the tool for any given spindle speed.

The quick-change gear device provides sixty changes for both the lead-screw and feed-rod. The lead-screw is cut from a special grade of steel, the method being one which provides extreme accuracy. The feed-rod drives the apron mechanism so that the lead-screw can be reserved exclusively for screw cutting. Graduated dials reading in thousandths of an inch are furnished on both the cross-feed and compound-rest screws. The rest has long bearings and is securely gibbed to the bed. The feed reverse lever at the front of the apron operates a double bevel pinion and may be set to feed in either direction, or in the neutral position where the gearing is disengaged. An automatic lockout connected with the reverse lever prevents the half-nuts from engaging with the lead-screw while the feeds are engaged, thus making it impossible to engage the lead-screw and feed-rod at the same time. The headstock and tailstock spindles are made of high-carbon crucible steel forgings and the tailstock is clamped to the bed by four heavy bolts. The spindle bearings are of bronze, securely fastened to the head and provided with efficient oiling facilities. The bed and large gears are made of semi-steel which gives close-grain castings, hard and tough. The lathe can be arranged for motor drive, in which case the motor is mounted on a bracket on the cabinet leg.



Reed 20-inch, Heavy-duty, Geared-head Lathe

NEW MACHINERY AND TOOLS NOTES

Cone Clutch: Sterling Elliott, Newton, Mass. A two-piece clutch intended for application on a variety of classes of machines.

Test Indicator: C. E. Robinson Co., 96 W. River St., Orange, Mass. This tool is equipped with a reversible dial which is graduated on both sides, one side giving readings in inches and the other in millimeters.

Bench Drilling Machine: G. R. Mellon, 14 East 17th St., Kansas City, Mo. A bench drilling machine equipped with a special form of rest which may be rapidly adjusted to accommodate different shapes of work.

Square and Hexagon Milling Fixtures: Garvin Machine Co., Spring and Varick Sts., New York City. A fixture designed for use on milling machines to meet the requirements of square or hexagon straddle milling.

High-duty Milling Machine: R. K. LeBlond Machine Tool Co., Cincinnati, Ohio. A new line of heavy-duty milling machines, equipped with single pulley drive. All changes are made by gearing. These machines are made in both the plain and universal types.

Traveling Crane Trolley: Whiting Foundry Equipment Co., Harvey, Ill. A new design of trolley for an electric traveling crane which has all of the gearing enclosed. The gears are placed inside the main bearings and only two reduction gears are used.

Sharpener for Vixen Files: Vixen Tool Co., 5001 Lancaster Ave., Philadelphia, Pa. A sharpening device which consists of a swivel grinding head carrying a fine grinding wheel of suitable shape and a sliding table on which the file, which is to be sharpened, is held.

Drafting-room Vertical File: Yawman & Erbe Mfg. Co., Rochester, N. Y. A vertical file designed for holding blueprints, drawings, and tracings in the drafting-room. This file keeps the sheets flat, and also enables them to be indexed so that any sheet may be readily located when it is required.

Portable Electric Grinders: The Van Dorn & Dutton Co., Cleveland, Ohio. A new line of electric grinding machines comprising the following types: a bench grinder, toolpost grinder, and an aerial grinder. The last type of tool is made in several styles, one of which is provided with a 12-inch extension.

Five-spindle Drilling Machine: Grant Automatic Machine Co., Detroit, Mich. This machine is provided with five horizontal spindles which are fed to the work by cams, and so timed that they enable one operator to handle all of the spindles. The camshaft is driven by a three-step cone and planetary gears.

Broaching Machine: The Lapointe Machine Tool Co., Hudson, Mass. A direct-connected motor-driven broaching machine with a stroke of 50 inches. The driving screw is 3¾ inches in diameter. The machine is adapted for operating at a rate of 54 inches per minute, and the geared return stroke is made at the rate of 240 inches per minute.

Electric Riveter: Eveland Engineering & Mfg. Co., Philadelphia, Pa. An electric riveting machine in which the rivet or rivet rod is heated by electric current and the head of the rivet shaped and pressed into place by a ram operated by a rack and pinion. The machine is adapted for working with rivets of any metal and of various diameters and lengths.

Large Motor-driven Lathe: Bridgeford Machine Tool Works, Rochester, N. Y. A 48-inch motor-driven lathe for use in the Gary plant of the American Bridge Co. The general design and construction of this machine is the same as the regular machines of this company's manufacture, with the exception of the increased length of the bed which adapts the machine for handling work up to 35 feet in length.

Universal Ball Vise: Adolph Muehlmatt, Cincinnati, Ohio. The "Rex" universal ball vise, as it is known, is mounted on a turntable revolving on a ball bearing. If desired, this bearing may be removed and the turntable locked to the base. The vise may be tilted to any desired angle in the ring pad upon which it rests, and the turntable, with the jaws, may be revolved to bring the work into the most convenient position for the mechanic.

Pipe Threading Machine: Pipe Machinery Co., 4907 Mead Ave., Cleveland, Ohio. A pipe threading machine designed for pipe mill work. One of the features of this machine is the complete enclosure of the gripping mechanism and all gearing. In this way, the machine is protected from damage and the safety of the operator is also provided for. The machine is driven by 3½-horsepower variable-speed motor supported on a bed bolted to the main bed of the machine at the rear.

Drilling and Tapping Machine: Kern Machine Tool Co., Hamilton, Ohio. A combination high-speed, ball-bearing, sensitive drilling and tapping machine adapted for use in factories engaged in the manufacture of such products as meters,

cash registers, and other light classes of work. The general construction is the same as that of this company's standard line of ball-bearing machines. The distinctive feature lies in the fact that the right-hand head pulleys are fitted with expanding ring frictions instead of with the positive clutch which is used on the drill for speed changing only.

Improvements on the "Lo-Swing" Lathe: Fitchburg Machine Works, Fitchburg, Mass. The improvements which this company has made on the "Lo-Swing" lathe of its manufacture comprise the following: tool-holders, a taper attachment of new design, a simpler and easier control of the gear-box mechanism, a roller bearing thrust collar on the spindle, swivel drive with a double-tail dog for high-speed work on heavy cuts, and an automatic measuring device which prevents errors being made in the length of stock for depth of centers, thus facilitating the production of duplicate parts.

Float Type Recording Differential Pressure Gage: The Bristol Co., Waterbury, Conn. A description of a new Bristol recording differential pressure gage was published in the April issue of MACHINERY. This company has also brought out a new float type of recording differential gage. This instrument has been developed to meet the requirements of classes of service for which the spring pressure tube type of differential gage is not adapted; *i. e.*, for very low ranges of differential pressure, in air, gases, liquids or steam. The use of this gage provides a continuous record of the rate of flow of the fluid, the differential pressure of which is being measured.

Press for Forming Automobile Side Frames: E. W. Bliss Co., 5 Adams St., Brooklyn, N. Y. This machine was built for one of the largest manufacturers of automobile parts in France, and is capable of forming side frames of ¼-inch chrome-nickel steel up to 18 feet in length. The moving table is raised by four connecting-rods which are fitted to the crankshaft, the connecting-rods being equally spaced. The machine is twin-driven, that is to say, it is provided with a gear on each end of the crankshaft. These gears are driven through triple reduction gearing, and the driving gear which transmits power to the main gears is placed centrally to overcome all torsional strain on the main backshaft. The control of the machine is effected by a double friction clutch which is operated by hand, thus giving the operator complete control of the moving parts at any point on the upward or downward movement of the press.

* * *

DISKS FOR ACCURATE ANGLE MEASUREMENTS*

BY GUY H. GARDNER†

For setting up a piece of work on which a surface is to be planed or milled at an exact angle to a surface already finished, the sine protractor, as shown in Fig. 1, with the height gage or with standard disks as shown in Fig. 2, furnishes

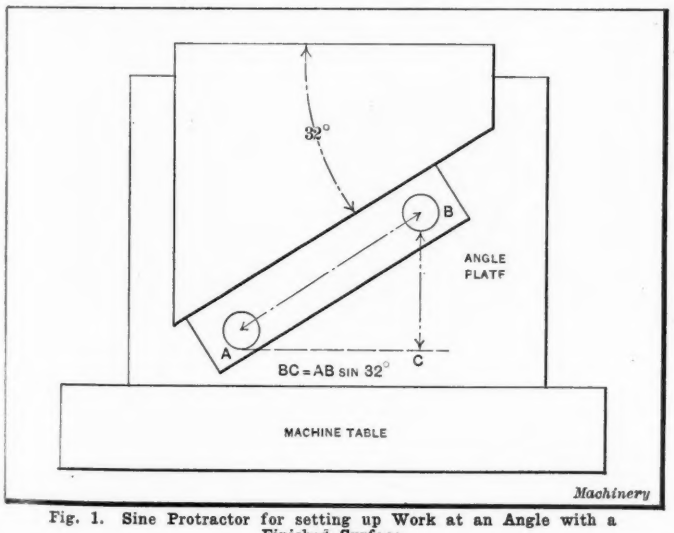


Fig. 1. Sine Protractor for setting up Work at an Angle with a Finished Surface

easy and accurate means of adjustment. But many mechanics who occasionally have to do work of this sort lack sine protractors and height gages, and many shops have no sets of standard disks. The object of this article is to suggest a ready means of attaining equal accuracy without these convenient but somewhat costly tools.

The one-inch disk, used for setting a two-inch micrometer, is within every mechanic's reach, and by making another disk of suitable size to be used in contact with the one-inch disk any angle up, to say about forty degrees, can be obtained with almost any desired limit of accuracy.

The formulas for disks in contact are:

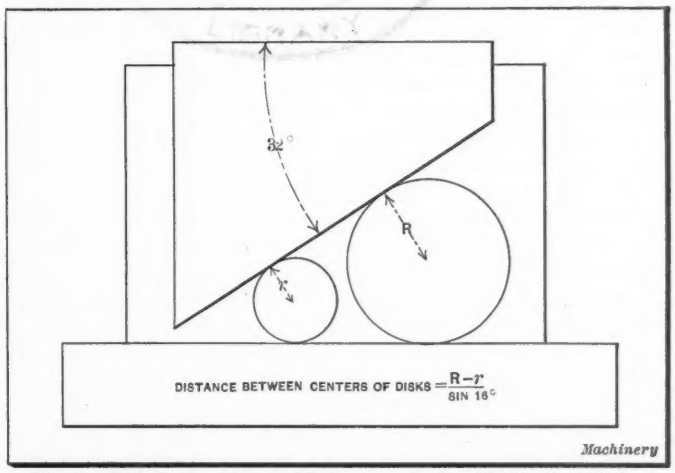


Fig. 2. Method of setting up Work at an Angle with Standard Disks

$$x = \frac{2r \sin \beta}{1 - \sin \beta}$$

and

$$x = \frac{2R \sin \beta}{1 + \sin \beta}$$

in which R = radius of larger disk.
r = radius of smaller disk.
$x = R - r$
β = one-half the desired angle.

Fig. 3 illustrates the method of use.

The accompanying table gives the sizes of the larger disks to the nearest ten-thousandth inch for whole degrees ranging

DISK DIAMETERS FOR ANGLE MEASUREMENT

Deg.	Inch	Deg.	Inch	Deg.	Inch	Deg.	Inch
5	1.0912	14	1.2775	23	1.4980	32	1.7610
6	1.1104	15	1.3002	24	1.5249	33	1.7934
7	1.1300	16	1.3234	25	1.5524	34	1.8262
8	1.1499	17	1.3468	26	1.5805	35	1.8600
9	1.1702	18	1.3708	27	1.6090	36	1.8944
10	1.1909	19	1.3953	28	1.6382	37	1.9295
11	1.2120	20	1.4203	29	1.6680	38	1.9654
12	1.2334	21	1.4457	30	1.6983	39	2.0021
13	1.2553	22	1.4716	31	1.7294	40	2.0396

Machinery

from five degrees to forty degrees inclusive. For other angles D can be found by simple arithmetical calculation, thus for an angle of 17 degrees, 26 minutes

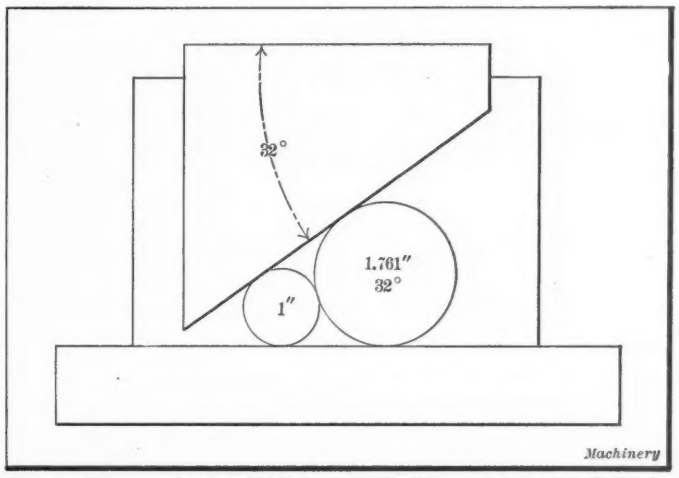


Fig. 3. Diagram showing Method of Angle Measurements with Disks in Contact

$$D = 1 + \frac{2 \sin 8 \text{ deg. } 43 \text{ min.}}{1 - \sin 8 \text{ deg. } 43 \text{ min.}} = 1 + \frac{0.3031}{0.84845} = 1.3572 \text{ inch.}$$

The usefulness of these disks can be increased by stamping on each, its diameter and also the angle which it subtends when in contact with the one-inch disk.

* For previous information on the use of sine bars for angular work, see "Use of Sine Bar for Measuring Angles," January, 1912.

† Address: New London, N. H.

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION CONVENTION

The semi-annual convention of the National Machine Tool Builders' Association was held May 15 and 16 at the Hotel Astor, New York City, Mr. E. P. Bullard, Jr., of the Bullard Machine Tool Co., presiding. The program of the convention included comparatively little of public interest, the work being done chiefly in committees and executive session. C. Wood Walter, of the Cincinnati Milling Machine Co., gave an interesting talk on his efforts in behalf of the present tariff on machine tools at Washington. Two new members were added to the association, *viz.*, the Cincinnati Electrical Tool Co., Cincinnati, Ohio, and Wickes Bros., Saginaw, Mich.

The association's differentiation of machine tool builders into classes, worked out under the direction of Mr. James H. Herron, general manager of the association, is given in the following list of committees. It will be noted that the committee of each main division is designated by a capital letter and the sub-divisions are indicated by lower case letters. Thus, Ba means the horizontal boring machine division of the boring machine committee:

(A) Bolt Threading Machine.
(B) Boring Machine. (a) Horizontal. (b) Vertical.
(C) Drilling Machine. (a) Electrical Portable. (b) Heavy Duty Box Column Type. (c) Radial. (d) Sensitive. (e) Vertical.
(D) Gear Cutting Machine.
(E) Grinding Machine. (a) Cylindrical. (b) Cutter and Tool. (c) Disk. (d) Drill. (e) Floor and Bench. (f) Internal. (g) Surface.
(F) Hammer.
(G) Lathe. (a) Plain. (b) Turret.
(H) Metal Sawing Machine.
(I) Milling Machine.
(J) Miscellaneous.
(K) Planing Machine.
(L) Press.
(M) Punching and Shearing Machine.
(N) Screw Machine. (a) Automatic. (b) Hand.
(O) Shaping Machine.
(P) Slotting Machine.

The matter of establishing a mechanical section was discussed and finally dismissed as being inadvisable. The association was originally organized for commercial purposes, and many of the members were of the opinion that a mechanical section would divert attention from the main object. The thought was expressed that the proper place for the presentation of mechanical papers is before the American Society of Mechanical Engineers, especially as that society has an organized committee on machine shop practice. Some expressions on the advisability of holding spring meetings in the future were voiced. A sentiment prevails that the association could do all the necessary business at the annual fall meetings, and by correspondence.

* * *

High-speed steel drawn accurately to size and coppered to prevent rust is one of the improved steel products that has come into use for tool making within the last few years. It can be ordered in many sizes, and being very close to specified dimensions requires little machining.

MAKING THE MARK COLD-DRAWN STEEL PIPE UNION

The Mark Mfg. Co., of Chicago, Ill., has just placed on the market a cold-drawn steel pipe union which is radically different from any other union heretofore produced. This union, as shown in Fig. 1, is made entirely from cold-drawn steel by a series of punch-press operations, and consists of the usual three main parts—male and female ends joined together by a coupling nut—the two ends being separated by a soft brass ring. These parts are completed, with the exception of threading, in powerful punch presses

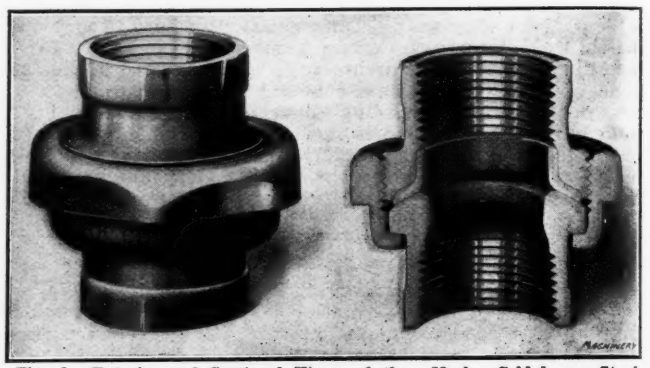


Fig. 1. Exterior and Sectional Views of the Mark Cold-drawn Steel Pipe Union

Fig. 2 illustrates the sequence of operations performed on the male member shown in Fig. 1. The first operation consists in cutting out the blank from ⅛-inch sheet steel; this blank is then drawn cup shaped and the bottom pierced out in the toggle drawing and deep stamping press with double roll-feeding attachment shown in Fig. 3. The appearance of the male part of the union after this operation is shown in Fig. 2. The next operation consists in folding over about one-quarter of the length of this cup, forming it into the shape shown. This is a very difficult operation, and is accomplished in a heavy Toledo punch press, equipped with a double-action toggle motion. The work when being formed into the shape shown is held in the lower die, and is first expanded by a taper-ended punch. Following this punch, and operated by the toggle action of the press is a sleeve

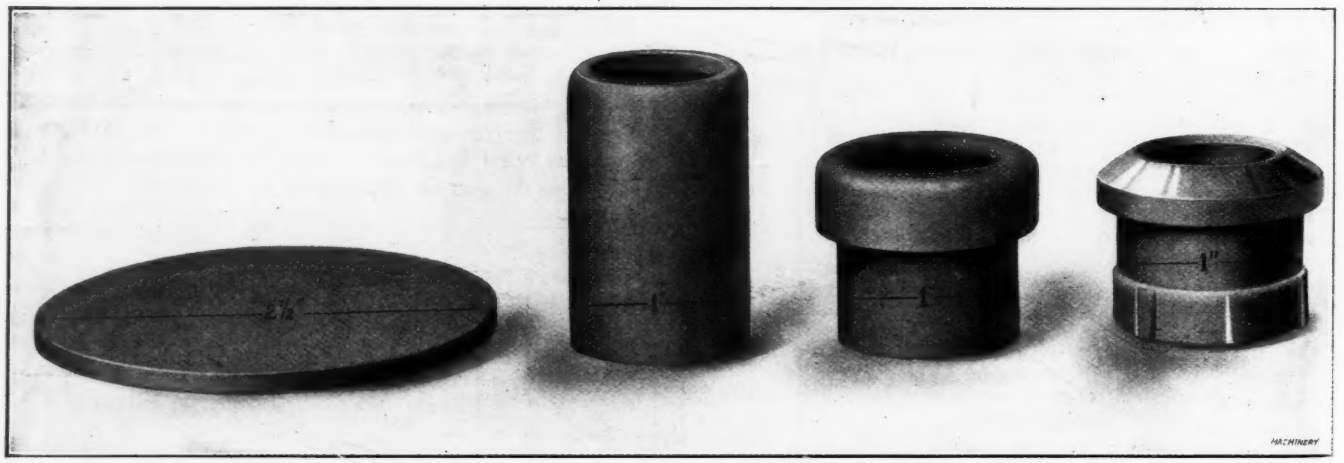


Fig. 2. Sequence of Punch Press Operations in the Formation of the Male Member of the Pipe Union shown in Fig. 1

which carries down the partially bent mouth of the shell and folds it over the body into the shape shown.

After folding over the top part of the shell, the next operation consists in forming the top part and embossing the lower end. This operation is accomplished in the special Toledo press, with two auxiliary slides, shown in Fig. 4. The two horizontal side members of this press carry the halves of an opening die in which impressions are made for forming the projections on the lower portion of the male member of the union. The upper part which has been folded over in the previous operation is formed to the desired shape by a suitably shaped die held in the ram of the press. This die, in addition to forming the top of the work, forces the metal down and expands it into the dies held in the side working members of the press.

The other parts of this union are carried through the forming operations in practically the same manner as the male member, and after being completed in the punch press they are taken to a threading machine and threaded. After threading, all the parts of the union pass through what is known as a sherardizing process. This consists in placing the articles to be sherardized in a drum or retort carrying zinc dust. The retort is then rolled into a furnace where the members are brought to the desired temperature. Subjecting the parts to this process causes the zinc to penetrate

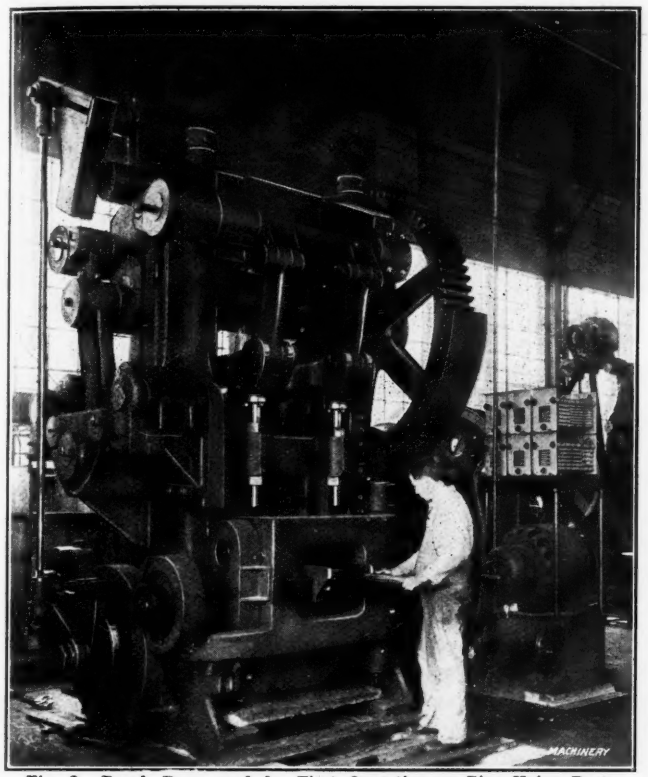


Fig. 3. Punch Press used for First Operation on Pipe Union Parts

a short distance into the metal, and also leaves a coating on its outer surface, thus making it rust-proof.

There are several superior qualities claimed for this type of seamless cold-drawn pipe union over those made by any other process, particularly casting. In the first place, the cold-drawn seamless union is free from sand holes and other structural defects; and as it is made from steel instead of malleable or cast iron, it is much stronger and hence can be subjected to greater pressures. In testing different makes of unions it was found that no two unions stood an equal pressure before leaking, thus showing a great lack of uniformity. It was also found that this lack of uniformity in most unions was due to the seats being imperfect, caused by shrinkage and flaws in the metal, and to irregularities inherent in the methods of manufacture. This uncertainty is practically eliminated in the Mark type of cold-drawn steel union, as the seat is formed by a very soft brass ring that makes the union leak-proof. As all the parts are passed through a sherardizing process, they are rust-proof. Another advantage obtained by using the Mark union is that it is made from the same material as is used in the manufacture of the pipe, and consequently its coefficient of expansion is the same. This is not the case with unions made from malleable iron or brass. It will therefore be seen that a pipe subjected to different temperatures has no tendency to shrink away from one of these cold-drawn steel unions, and, therefore, obviates the possibility of leakage. The contact surfaces of the members of the union against the brass ring are also considerably harder than the other portions of the body, which, of course, is due to the great pressure to which these parts are subjected when formed in the punch press.

The manufacturing plant in which these unions are produced is a little out of the ordinary, and is worthy of mention. It will be seen in Figs. 3 and 4 that the punch presses shown are equipped with electrical controllers, this being a further development of the electrical method of driving punch presses. The operation of the punch press is controlled entirely by the electrical rheostat, which in Fig. 3 is placed at the side of the press with the motor, and in Fig. 4 at the top of the press. The electric control is operated by the handwheel shown in Fig. 4, and governs the operation of the press, enabling the ram to be stopped at any point of its travel.

* * *

While there is yet much to be done before the aeroplane will become a practical and, generally speaking, useful machine, it must be admitted that it has fully passed its experimental stage, when it has now become possible to cover over five hundred miles in a cross-country flight without a stop. This was accomplished on May 1, by a French aviator, Gilbert, who flew continually for 8½ hours from Paris to Vittoria, Spain, a distance of 513 miles. Another remarkable flight was made by a Frenchman, Guillaux, who on April 27 and 28 covered over one thousand miles in less than 24 hours, descending twice on this trip. Another Frenchman, Daucourt, recently flew from Paris to Berlin, a distance of 555 miles with only two stops, one at Liege and one at Hanover, the actual flying time being less than 9 hours. The 211 miles between Paris and Liege were covered in 2½ hours, or at an average speed of 85 miles per hour.

* * *

Among the interesting collection of fixed ammunition shown by the Union Metallic Cartridge Co. at its Bridgeport factory, are some metallic cartridges of the style used by Chinese Gordon in his defense of Khartum which ended in the annihilation of the British forces in 1885. These cartridge cases were reduced at the mouth to bottle-neck form, but the reducing operation was so poorly done that the metal was crushed into deep folds and wrinkles, the appearance

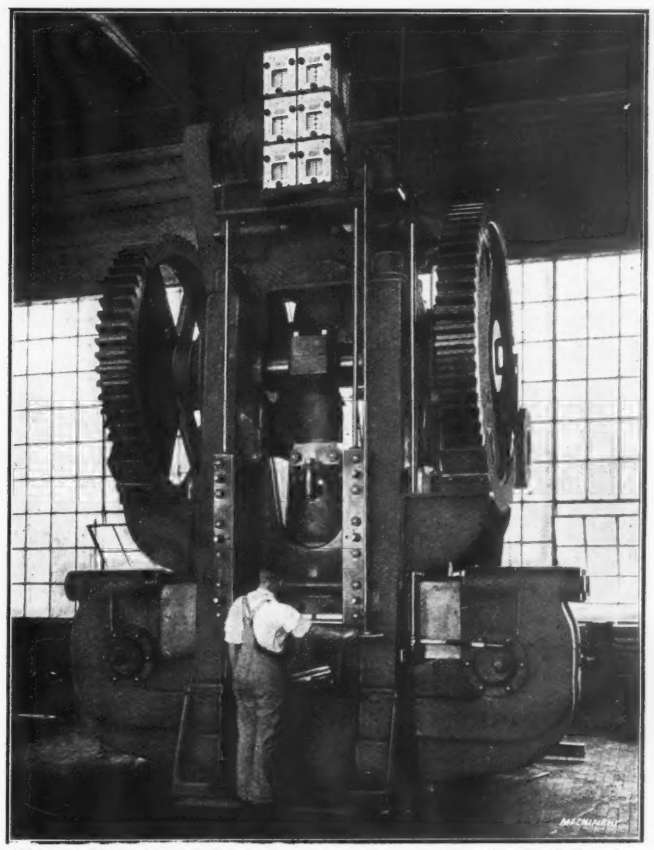


Fig. 4. Large Special Toledo Press used in performing the Final Forming Operations on the Pipe Unions

being very crude as compared to the smooth work now done by cartridge makers. The failure of the British cartridge makers to produce smoothly reduced shells is said to have been directly responsible for the disaster to the British forces when the wild fanatical Mahdists charged. Sand from the desert lodged between the rough cartridge cases and the chamber walls of the barrel was so firmly imbedded in the shell and barrel after firing that the soldiers could not extract the empty shells. Hundreds of muskets were found after the battle in a useless condition because of stuck shells in the chambers.

FIXTURE FOR GRINDING VALVE PUSH-RODS

The grinding of valve push-rods to the proper length is an operation which is not usually handled at a very rapid rate, owing to the accuracy required and also to the fact that they must be ground on both ends. Several methods are employed for this work, one of which is shown in the accompanying illustrations. Fig. 3 shows how this operation is handled in the plant of the Ford Motor Co., Detroit, Mich., where a Blanchard vertical surface grinder, provided with two fixtures *A* and *B*, is used. Each of these fixtures is designed for holding 104 rods (shown in detail in Fig. 1), and both ends of the push-rods are ground without removing the rods from the fixture after they have been clamped in place. The Blanchard vertical surface grinder shown is provided with a magnetic chuck for holding the fixtures carrying the work.

For the first operation, which is shown in Fig. 3, and at *A* in Fig. 2, the tops or largest diameters of the push-rods are ground—about 0.010 inch being removed—and when this operation is being accomplished, a blocking ring of the inverted T-section, as shown at *C* in Fig. 2, is placed under the fixture. This raises the fixture from the magnetic chuck

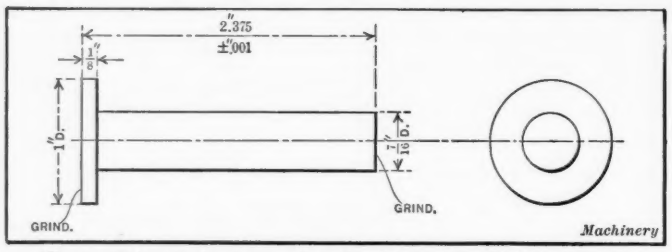


Fig. 1. Valve Push-rod ground to Exact Length in Fixture shown in Figs. 2 and 3

and prevents the push-rods from touching. For the second operation—the grinding of the small end of the rods—the blocking ring *C* is removed and the fixture is located on the table as indicated at *B* in Fig. 2, the previously ground faces of the rods resting on the magnetic chuck. This feature is worth calling attention to, as it enables greater accuracy to be obtained, owing to the fact that the fixture does not intercept the rods and the surface of the magnetic chuck.

Referring to Fig. 2, where the details of this interesting valve push-rod fixture are shown, it will be seen that the method of clamping is simple and consists of two blocks *a* through which passes a shouldered binding stud *b*. This stud, in connection with the two clamps, holds four push-rods in place. The studs are prevented from turning by headless screws *c* resting on a flat provided on the studs. The rods are held in V-grooves in the body of the fixture and are located when being placed in the fixture by the under surface of the heads which rests on the finished top

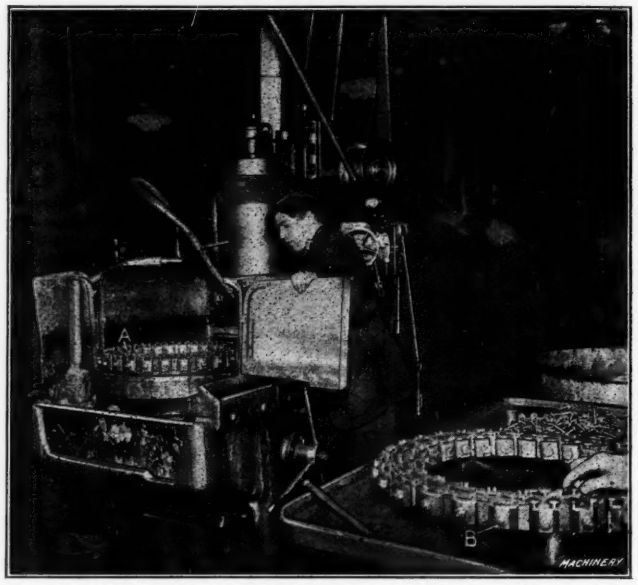


Fig. 3. Grinding Valve Push-rods on a Blanchard Vertical Surface Grinder at the Rate of 720 per Hour

face of the fixture. Two of these fixtures, as shown in Fig. 3, are provided so that when one is on the machine, the other fixture is being loaded by the operator. This enables the grinding operation to be carried on practically continuously and makes possible the enormous production of 720 rods per hour. The fixture shown in Figs. 2 and 3 was designed and built by the Blanchard Machine Co., Cambridge, Mass. D. T. H.

* * *

The New York, New Haven & Hartford Railroad Co. a short time ago offered a prize of $10,000 for an automatic stop device to meet certain requirements laid down by the railroad. In response to this offer, 1574 automatic stop devices were submitted to the company. Of these, two devices have been selected for experiment on the railroad. The engineers of the company have stated that neither of these devices can be considered perfect in themselves, but that they are worthy of trial installation.

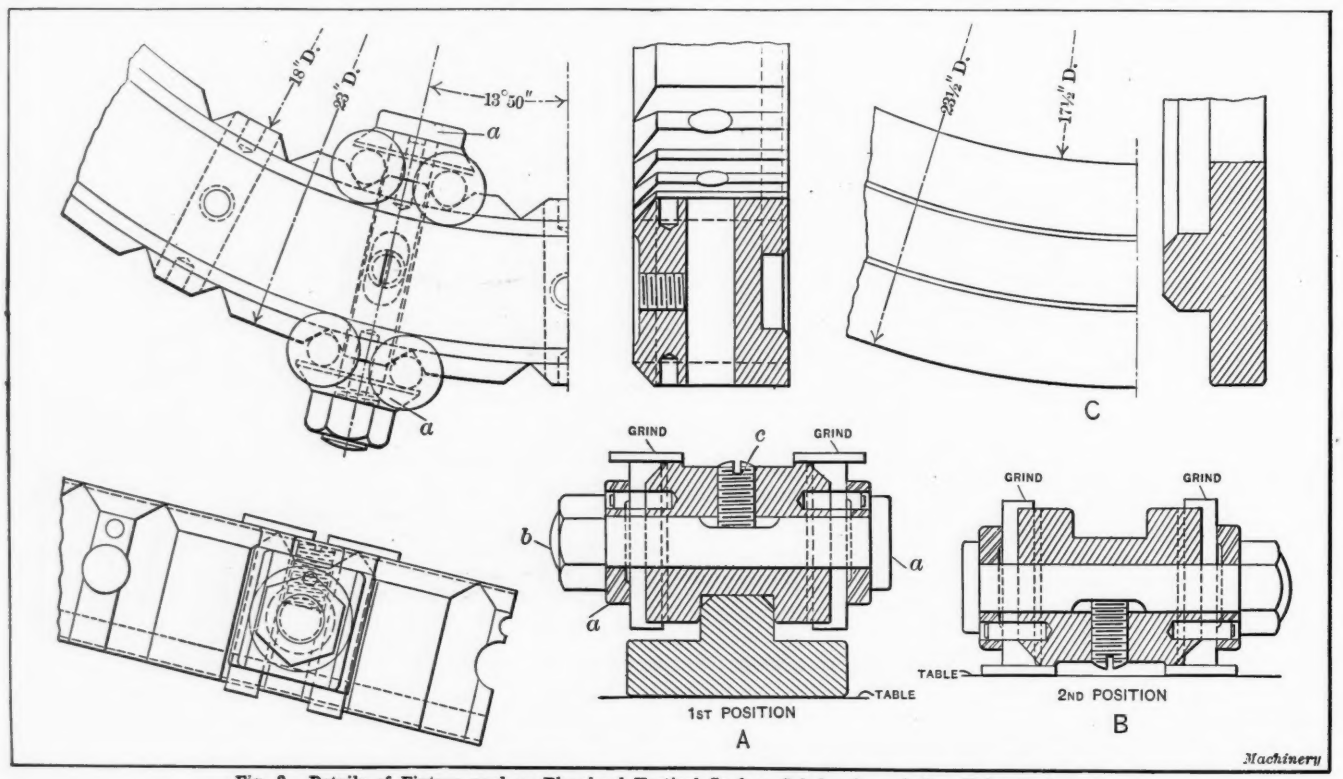


Fig. 2. Details of Fixture used on Blanchard Vertical Surface Grinder for grinding Valve Push-rods

SPRING MEETING OF THE A. S. M. E.

The spring meeting of the A. S. M. E., was held in Baltimore, Md., May 20-23, at the Hotel Belvedere. The meeting was in charge of Dr. W. F. M. Goss, president, and Calvin W. Rice, secretary. The technical program comprised the following papers and reports:

Reports of special committees on myriawatt, involute gears and code of ethics.

"Test of a Hydraulic Buffer," by Carl Schwartz.

"The Present Condition of the Patent Law," by Edwin J. Prindle.

"Shading in Mechanical Drawing," by Theodore W. Johnson.

"Cost of Upkeep of Horse-drawn Vehicles against Electric Vehicles," by W. R. Metz.

"Present Operation of Gas Engines using Blast-furnace Gas as Fuel," by Charles C. Sampson.

"The Baltimore High-pressure Fire Service," by James B. Scott.

"National Standard Hose Couplings and Hydrant Fittings for Public Fire Service," by F. M. Griswold.

"Debarment of City Conflagrations," by Albert Blauvelt.

"Allowable Height and Area in Factory Buildings," by Ira H. Woolson.

"The Protection of Main Belt Drives with Fire Retardant Partitions," by C. H. Smith.

"The Life Hazard in Crowded Buildings due to Inadequate Exits," by H. F. J. Porter.

An informal reception was held Tuesday evening by the officers of the Engineers' Club of Baltimore, and on Wednesday afternoon a demonstration of the high-pressure fire system was made on the City Hall plaza. This was followed by an inspection of the pumping station on South St. A trip was made around the harbor on the municipal steamer *F. C. Latrobe*, and Wednesday evening a lecture, illustrated by lantern views entitled "Around the World in Eighty Minutes," was given by the Hon. O. P. Austin, secretary of the National Geographic Society.

On Thursday, the members made an inspection of the Jones' Falls conduits, the sewage pumping plant in Baltimore, and the sewage disposal plant at Back River. In the evening a reception and dance was tendered the members of the society by the Engineers' Club of Baltimore in the ball room of the Hotel Belvedere.

On Friday, an excursion was made to Annapolis, the capital of Maryland, and the U. S. Naval Academy. The party was met at the State House by Governor Goldsborough, who delivered an address of welcome. Flights of the two Wright and three Curtiss hydro-aeroplanes were made, and members of the visiting party were taken up for short flights. At the Naval Experiment Station, investigations were in progress on the corrosion of metals, boiler compounds, lubricants, metals, strength of materials, endurance of metals, etc.

* * *

"FIGURING OUT GEARS FOR SPEED BOXES"

Formula (5) in the article "Figuring Out Gears for Speed Boxes," published in the April number, reads

$$B = \frac{J - C}{\sqrt{\frac{JG}{C} - 1}}$$

The formula should be corrected to read thus:

$$B = \frac{J - C}{\sqrt{\frac{JG}{C} - 1}}$$

* * *

Work has begun on a hydro-electric power plant in Switzerland which will use a water head of 5412 feet. The plant will be located near Martigny in the Canton of Wallis. The pipe line at the lower end must be constructed to withstand a pressure of 2400 pounds per square inch. The length of the line will be 2¾ miles, and its inside diameter will vary from 20 to 24 inches, while the thickness of the walls will vary from ¼ to 1¾ inch. The upper sections of the pipe will be of the lap-welded type, while the pipes at the lower part will be seamless. Each of the turbines used will be 15,000 horsepower capacity.

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A feature of milling machine practice that often receives scant attention is making the mills of a gang as large as possible in order to reduce the disproportion of diameters. When a three-inch mill is working in the same gang with a six-inch mill, the peripheral speed has to be kept within the maximum speed capacity of the six-inch mill, which means that the three-inch mill is running far below its maximum peripheral speed. On the other hand the feed is limited to the capacity of the three-inch mill. Thus one cutter is working at one-half its peripheral cutting speed and the other at one-half its feed capacity. Now, if the diameter of the small mill is made six inches and that of the larger one nine inches the same form will be produced and the production capacity may be increased fully fifty per cent. The force of this is evident. The same condition has been observed in the use of dovetail cutters when the width of the dovetail affords plenty of room for a large diameter cutter. Examples of dovetail cutters have been noted having a small diameter of 1¼ inch and a large diameter of three inches. In this case the loss of efficiency is even greater than in the first mentioned case.

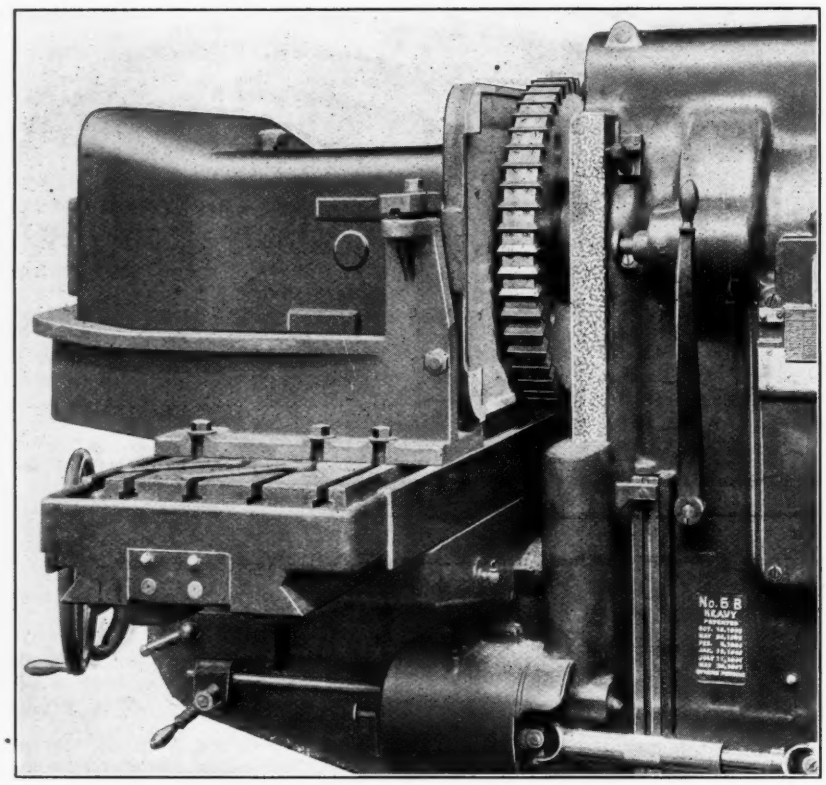
* * *

PERSONALS

F. E. Gardner, vice-president of the Gardner Machine Co., Beloit, Wis., who has been seriously ill, has greatly improved, and will fully recover.

John J. Hannigan has joined the Bath Grinder Co., Fitchburg, Mass., to take charge of the company's advertising, succeeding Mr. S. W. Mathias, resigned.

1000 lbs. on the Table of the No.



Milling Base of Automatic Screw Machine Bed

Casting, as it is fastened on machine, is 25" high and extends 35" out from cutter. Work and fixture combined weigh about 1000 lbs. The B. & S. Inserted Tooth Face Mill is 26" in diameter.

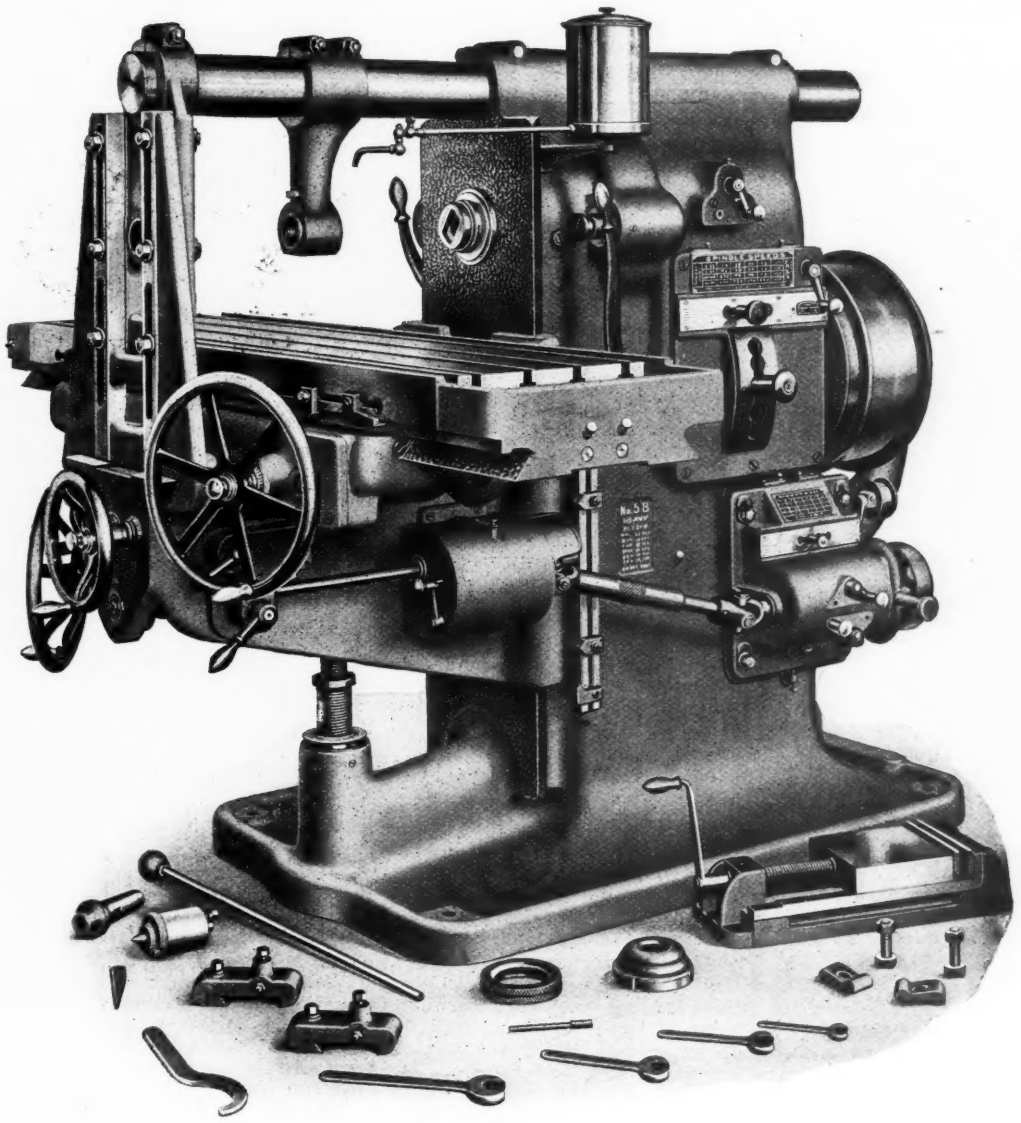
Put Your Big Jobs on this Machine.
It is Built for Heavy Service.

BROWN & SHARPE MFG. CO.,

OFFICES: 20 Vesey St., New York, N. Y.; 654 The Bourse, Philadelphia, Pa. 626-30 Washington Blvd., Chicago, Ill. 305 Chamber of Commerce Bldg., Rochester, N. Y.; Room 429, University Block, Syracuse, N. Y.

REPRESENTATIVES: Baird Machinery Co., Pittsburgh, Pa., Erie, Pa.; Carey Machinery & Supply Co., Baltimore, Md.; E. A. Kinsey Co., Cincinnati, O.; Indianapolis, Ind.; Pacific Tool & Supply Co., San Francisco,Cal.; Strong, Carlisle & Hammond Co., Cleveland, O., Detroit, Mich.; Colcord-Wright Machinery & Supply Co., St. Louis, Mo.; Perine Machinery Co., Seattle, Wash.; Portland Machinery Co., Portland, Ore.

5 B Heavy Plain Milling Machine



The machine has the requisite power, strength and rigidity to pull deep cuts and support heavy loads.

Capacity 50" x 12" x 21".

Driving pulley 20" diameter, runs 320 R.P.M., 7" belt.

PROVIDENCE, R. I., U. S. A.

Canadian: The Canadian-Fairbanks-Morse Co., Ltd., Montreal, Toronto, Winnipeg, Calgary, Vancouver, St. John, Saskatoon.
FOREIGN: Buck & Hickman, Ltd., London, Birmingham, Manchester, Sheffield, Glasgow; F. G. Kretschmer & Co., Frankfurt, a/M., Germany; V. Lowener, Copenhagen, Denmark, Stockholm, Sweden, Christiania, Norway; Schuchardt & Schutte, St. Petersburg, Russia; Fenwick Freres & Co., Paris, France, Liege, Belgium, Turin, Italy, Zurich, Switzerland, Barcelona, Spain; F. W. Horne, Tokio, Japan; L. A. Vail, Melbourne, Australia; F. L. Strong, Manila, P. I.

Read page 69

H. L. Babcock, formerly of the H. H. Franklin Mfg. Co., Syracuse, N. Y., is now representing the E. B. Van Wagner Mfg. Co., of Syracuse, in the Middle West.

R. K. LeBlond, president of the R. K. LeBlond Machine Tool Co., Cincinnati, Ohio, will sail for Europe June 10, on the *Victoria-Louise*, for a three months' business and pleasure trip.

George C. Bardons, of Bardons & Oliver, Cleveland, Ohio, manufacturers of turret lathes, sailed for Europe May 10, on the *Friedrich Wilhelm*. Mr. Bardons will spend six weeks in England, Scotland and Wales.

C. C. Gressle has been made superintendent of the Standard Welding Co., Cleveland, Ohio. Mr. Gressle has held high positions in the factory organization of the company since its inception, about fifteen years ago.

Dyer Smith, at one time associate editor of MACHINERY, has removed his office from 2 Rector St., New York City, to the Woolworth Building, where he will continue his practice as heretofore in connection with patents, patent cost, trademarks and copyrights.

Frank Horsburgh, president and general manager of the Horsburgh & Scott Co., Cleveland, Ohio, will sail, accompanied by his wife, on the *Saxonia*, June 12, for a three to four months' tour in Europe, landing at Italy, and also visiting France, Germany, Switzerland, Holland, Belgium and England.

Arthur Williams, president of the American Museum of Safety, New York, was decorated May 2 with the Cross of Isabela de Catolica in recognition of his work as a promoter of industrial safety. The presentation of the decoration was made the occasion of a testimonial banquet at Sherry's, New York City.

A. W. Morris, formerly of the Morris Mfg. Co. and the Wetherill Finished Castings Co., has joined the Doehler Die-Casting Co., Court and Ninth Sts., Brooklyn, N. Y., maker of die-castings, etc., as factory manager. The Wetherill Finished Castings Co. and the Morris Mfg. Co., have discontinued business and dissolved.

G. E. Stoy has resigned his position as general foreman of the Trinity & Brazos Valley shops, at Galveston, Texas, to take charge of the locomotive department of the Vandaveer Clay Products Co., of Houston, Texas. Mr. Stoy will have charge of all installations of this company's patent locomotive firebox liners and oil burners.

William Newell, mechanical engineer of the New York State Department of Labor and author of the specifications on exhaust systems published in the May number, will act in an editorial capacity with *Safety Engineering*, having charge of the accident prevention department. Mr. Newell will be assisted by Mr. David Van Schaack, director of the Bureau of Inspection and Accident Prevention of the Aetna Life Insurance Co.

E. T. Enlow has resigned as manager of the Stark Rolling Mill Co., Canton, Ohio, and become associated with the Pedlar People, Oshawa, Ontario, Canada. Mr. Enlow has been active in the sheet metal trade of the United States for the past twenty years. While with the Stark Rolling Mill Co., he was closely identified with the sale of "Toncan" metal and will continue in that relation with the Pedlar People who are large sheet metal factors in Canada.

H. T. Latto, who has for several years been connected with the sales department of the National-Acme Mfg. Co., Cleveland, Ohio, has been appointed Eastern sales manager of the company to succeed Mr. L. M. Waite. Mr. Latto will have charge of the Eastern office and warehouse at 77 White St., New York City, after the middle of May, and will direct the work of the company's sales organization in Eastern Pennsylvania, Eastern New York, New Jersey, Maryland, Delaware and Virginia.

S. W. Hartley has been appointed sales manager of the Standard Welding Co., Cleveland, Ohio, succeeding J. C. Manternach, who has been promoted to the position of general manager. Mr. Hartley was assistant sales manager of the Standard Welding Co., for over two years. He has been prominently identified with the engineering of the motor car industry in the United States from its beginning. He was formerly with the Peerless Co., of Cleveland, Ohio, the Garford Co., of Elyria, Ohio, and the A. O. Smith Co., of Milwaukee, Wis.

R. S. Bryant has been made consulting engineer of the Standard Welding Co., Cleveland, Ohio. He is the designer of the first quick-detachable rim in America and has been in the employ of the company about two years. He is the originator of the types of rims now being made and sold by the company, and the designer of many other styles that have had notable success. He also built and perfected the first specialized machines for the manufacture of automobile rims. Mr. Bryant was the founder of the Bryant Rim Co., Columbus, Ohio, which was purchased by the Diamond Rubber interests several years ago.

F. N. Gardner

J. C. Manternach, formerly sales manager of the Standard Welding Co., has been appointed general manager of the company, succeeding Tracy W. Guthrie, resigned. Mr. Manternach was appointed sales manager of the Standard Welding Co., by the late W. S. Gorton, and his present advancement is the result of his efficient efforts in behalf of the company. He has been identified with the American steel tube industry practically from its infancy. He began with the Pope Mfg. Co., Hartford, Conn., in 1897 and later was with the Shelby Steel Tube Co., and the National Tube Co. He is widely known among those connected with the bicycle, motorcycle, automobile and steel tube industries.

OBITUARIES

J. L. A. Wheeler, superintendent of the Frick Co., Waynesboro, Pa., died April 19.

James R. Huber, western sales representative of the Lumen Bearing Co., Buffalo, died from pneumonia at his home in Detroit, May 8.

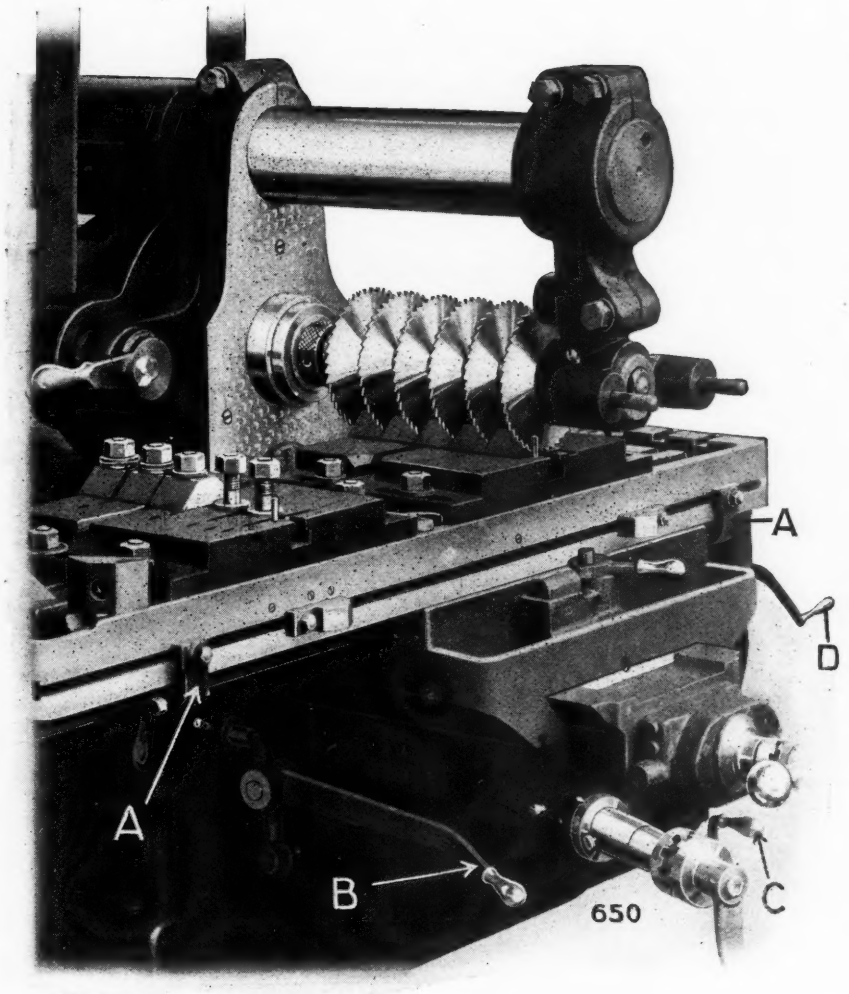
Francis M. Rites, inventor of the inertia governor for steam engines, and a well-known mechanical engineer, was found dead in his home, near Ithaca, N. Y., May 9.

DANIEL SIMONDS

Daniel Simonds, president of the Simonds Mfg. Co., Fitchburg, Mass., died May 4 at his summer home at Larchmont, L. I., at the age of sixty-five years. He was born in Fitchburg, 1847, and attended the public schools and the Comer's Commercial College of Boston. After leaving college, he went to work for his father in West Fitchburg, making scythes and edge-tools. In 1868 the Simonds Mfg. Co. was incorporated. This company took over the business organized by Abel Simonds, Mr. Daniel Simonds' father, and the latter held various positions with the new company until in the early eighties he was made superintendent and vice-president, and in 1888 president of the concern. The business has steadily grown under Mr. Simond's leadership. In 1900, the company built a steel plant and began the manufacture of steel in Chicago. In 1905 the Fitchburg File Works was bought, and in 1906 the firm acquired four plants in Montreal. Mr. Simonds was the moving spirit in the cooperative industrial system of education at the high school, which has widely advertised Fitchburg throughout the country. He was a director of the Fitchburg National Bank and Fitchburg Mutual Fire Insurance Co., and a member of several business associations and clubs. He is survived by a widow and three sons, A. T. Simonds, of Lockport, N. Y., and G. K. Simonds and H. K. Simonds, of Fitchburg, Mass.

F. N. GARDNER

F. N. Gardner, president of the Gardner Machine Co., Beloit, Wis., died of pneumonia at the Beloit Hospital, May 11, aged sixty-four years. Mr. Gardner was sick only a few days, and his death caused a great shock to the business community of Beloit and to his many friends throughout the country. He was born at Ashfield, Mass., September 4, 1848. At the age of fifteen he began to learn the trades of machinist and toolmaker in the Wiley & Russell Shops at Greenfield, Mass. Later he continued his apprenticeship with John J. Grant in Northampton, Mass. After having completed a total of seven years apprenticeship, he went to Hartford, Conn., where he was employed for many years by the Pratt & Whitney Co. During the last years that he was connected with this company he had charge of what is now known as the "small tool department." Mr. Gardner also was connected with the Hartford Tool Co. In 1888 he came to Chicago for the purpose of selling the Pratt & Whitney Co.'s products for C. H. Besly & Co., who then represented the former



Continuous Milling

The desired section is machined in economical manufacturing lengths, and then sawed to finished size in 7/10 minutes, each piece.

When your work permits, it's often a good plan to keep a number of the pieces joined together for the earlier machining operations and to separate them afterwards with a gang of saws.

There's no idle travel on the first milling operations because there is no space between pieces.

Only one clamping needed for several pieces. The drilling can be handled on a multi-spindle machine.

Then on the last operation of sawing apart you get CONTINUOUS MILLING—PROVIDED ALWAYS—that your machine has sufficient power to pull the gang of saws as fast as the operator can chuck the pieces.

AND that the vertical feed engaging and reversing levers are operated from the front of the knee.

The No. 2 CONE TYPE CINCINNATI MILLING MACHINE illustrated above is sawing up a bar from which we make 5 gibs.

The bar is milled to section and drilled before this operation. It is clamped to one of two plates and is located under the saws by the hand stop A on the front of the table. The vertical feed is engaged through lever B.

At the conclusion of the cut the trip dog throws out the feed which is then reversed through lever C. During this time the operator has removed the separated pieces and clamped a new bar in the other fixture.

With the quick return handle D he brings the table over to the second hand stop A and repeats the process.

The "Cincinnati" control makes this cycle of movements simple.

Note how all the levers are grouped at, and can be operated from, the front of the knee.

Speed 60 R. P. M.
Feed .013 in. per rev.
Width of each cut $\frac{1}{8}$ x 3$\frac{1}{2}$.
Depth of cut 1$\frac{1}{4}$ in.
Metal removed 1.8 cu. in. per min.
Time 7/10 minutes.

Doesn't this apply to some of your work?

THE CINCINNATI MILLING MACHINE CO.

CINCINNATI, OHIO, U. S. A.

company in the West. In 1890 he became superintendent and general manager of the works of C. H. Besly & Co., of Beloit, and remained for several years with this firm, during which period he developed the disk grinder, forged taps, and other specialties. Mr. Gardner was the inventor of the disk grinder which has become recognized the world over as a machine tool of extraordinary capacity for roughing and finishing metal work. While with C. H. Besly & Co., the disk grinder part of the business became an important part of the manufactured product. In 1905, Mr. Gardner organized the Gardner Machine Co., having interested local capital in his enterprise, and built a factory in Beloit for building disk grinders and other machines.

Mr. Gardner was an expert toolmaker. While with the Hartford Tool Co.—an association of E. G. Parkhurst, M. D. Pratt, J. E. Woodbridge and Mr. Gardner—he developed a method of making knife-edge straightedges and produced straightedges that had never been equalled before for accuracy. He is credited with being the inventor of the deep hole drill of the type having oil ducts or tubes in the body of the drill for carrying lubricant under pressure to the point of the drill, where it not only lubricates the cutting edge, but forces out the chips as rapidly as they are formed. This important improvement in drills was made about 1886, while employed by the Pratt & Whitney Co., under Mr. Heyer on the "reamer job." This tool made possible the rapid drilling of deep holes of small diameter very straight. The deep hole drill of the forced lubrication type is used for gun barrel drilling generally in the armories of the world.

Mr. Gardner was a man of pleasing personality and had many friends. He was closely identified with the local activities of Beloit, belonging to various fraternal societies and other organizations. He was greatly interested in improving conditions in and around Beloit, and was active in the movement for deepening the channel of Rock River, so as to make it navigable by steamers the year round. Mr. Gardner is survived by Mrs. Gardner, two daughters and five sons—Fred E., John M., Charles E., Edward B., and Ralph Gardner.

COMING EVENTS

June 5-7.—Semi-annual meeting of the Society of Automobile Engineers and Joint meeting of the Institution of Automobile Engineers (of England) and the Society of Automobile Engineers (of America) to be held on board the steamship "City of Detroit III" cruising on the great lakes. The steamer leaves Detroit, Mich. on the afternoon of June 4. Coker F. Clarkson, secretary of General Committee of Arrangements, 1451 Broadway, New York City.

June 10.—Departure from New York City of American Society of Mechanical Engineers' party to attend joint meeting with Verein deutscher Ingenieure in Leipzig, Germany, beginning June 23.

June 11-13.—Annual convention of the American Railway Master Mechanics' Association at Atlantic City, N. J. Joseph W. Taylor, secretary, Old Colony Bldg., Chicago, Ill.

June 16-18.—Annual convention of the Master Car Builders' Association at Atlantic City, N. J. Joseph W. Taylor, secretary, Old Colony Bldg., Chicago, Ill.

August 16-23.—Second Annual Gas Engine Show of the National Gas Engine Association at Kansas City, Mo. H. R. Brate, secretary, Lakemont, N. Y.

September 17-23.—Third International Congress of Refrigeration to be held in Chicago, Ill. For further information address the secretary-general, J. F. Nickerson, 431 South Dearborn St., Chicago, Ill.

October 10-17.—Eighth Annual Foundry and Machine Exhibition in the International Amphitheater Bldg., Chicago, Ill. This exhibit, which was started eight years ago to show foundry equipment only, has broadened out considerably in the past few years and now includes all classes of machine tools and shop equipment as well as foundry equipment and supplies. Forty-five concerns were represented in the exhibition held in Buffalo last year. C. E. Hoyt, secretary, Lewis Institute Bldg., Chicago.

October 14-16.—Annual convention of the Allied Foundrymen's Association. Hotel La Salle, headquarters. Richard Moldenke, Watchung, N. J., secretary.

February 20—December 4, 1915.—Panama-Pacific International Exposition, San Francisco, Cal. Charles C. Moore, president; Rudolph J. Taussig, secretary.

SOCIETIES, SCHOOLS AND COLLEGES

University of Nebraska, Lincoln, Neb. Annual catalogue of the College of Engineering for the year 1913-14.

Polytechnic Institute of Brooklyn, Brooklyn, N. Y. Catalogue of the College of Engineering for the year 1913-14.

American Museum of Safety, 29 West 39th St., New York City, issues a publication regularly called "Safety," devoted to accident prevention, hygiene, mutuality and the cause of the better industrial working conditions generally.

Louisiana State University, Baton Rouge, La. Catalogue of the university for the year 1913, giving information concerning the courses of study offered, the various student organizations and other matters of timely interest to both students of the university and those who intend entering upon courses of study.

Pratt Institute, Brooklyn, N. Y., will make its annual exhibit of the work of day students June 12-14. The exhibit is open to the public and affords those who are interested in industrial and technical education an opportunity not only of viewing the work of students in various courses, but of inspecting the methods as well as the equipment of the school and its general facilities for giving technical training. The school provides instruction in applied mechanics, applied electricity, applied chemistry and tanning, machine work and toolmaking, carpentry and building and patternmaking; besides a great variety of vocational subjects for young men and women.

NEW BOOKS AND PAMPHLETS

Road Models of the Office of Public Roads. 45 pages, 6 by 9 inches. Illustrated. Published by the U. S. Department of Agriculture, Washington, D. C., as Bulletin No. 47.

Entropy-Temperature and Transmission Diagrams for Air. By C. H. Richards. 20 pages, 6 by 9 inches, three folding plates. Published by the University of Illinois Engineering Experiment Station, Urbana, Ill., as Bulletin No. 63. Price 25 cents.

Past and Present Metal Markets. By W. E. Figgis. Part I. 46 pages, 5 by 8½ inches. Part II, Charts A and B. Published by Critchley Parker, Melbourne, Australia. Price 15 shillings net.

The booklet reviews the fluctuation of prices of copper, tin, zinc, lead and silver. Chart A shows the price fluctuations of copper and tin from the year 1890 up to the present and chart B the fluctuations of zinc, lead and silver for the same period.

Steel: Its Selection, Annealing, Hardening and Tempering. By E. R. Markham. 367 pages, 7½ by 5⅝ inches. 168 illustrations. Published by the Norman W. Henley Publishing Co., 132 Nassau St., New York City. Price $2.50.

The present is the fourth edition of this work, which was formerly known as "The American Steel Worker." The present edition has been thoroughly revised and, as the title implies, it constitutes a comprehensive text on the selection of tool steel and methods of heat-treatment.

Practical Geometry and Graphics for Technical Students. By Edward L. Bates and Frederick Charlesworth. 621 pages, 4¾ by 7¼ inches. Published by D. Van Nostrand Co., 25 Park Place, New York City. Price $2.00 net.

This work, which is intended to be a text-book for students in technical and trade schools, evening classes, etc., treats of plane geometry, graphics and descriptive geometry, giving numerous illustrations and examples for practice. The ground covered comprises a two or three years' course of instruction, according to the ability of the student.

Descriptive Geometry. By Adam V. Millar and Edward S. Maclin. 131 pages, 5 by 7½ inches. Published by McGraw-Hill Book Co., New York City. Price $1.50 net.

The work treats of projection, orthographic projection, picturing magnitudes in space, points, lines, planes, revolution and counter-revolution, line conventions, the elementary principles of the point, straight line, and plane; applications of the elementary principles of the point, straight line, and plane; curved lines and surfaces, plane sections and developments of curved surfaces, intersections of curved surfaces.

Characteristics and Limitations of the Series Transformer. By A. R. Anderson and H. R. Woodrow. 45 pages, 6 by 9 inches. Published by the University of Illinois Engineering Experiment Station, Urbana, Ill. Price 25 cents.

The bulletin treats of the characteristics of the series transformer and the theory of the transformer based on instantaneous current values. It is the purpose of the bulletin to show the imperfections of the transformer and to determine how and to what extent certain constants influence its operation. A comparison of results obtained and a general summary are given in conclusion.

Wastes in the Production and Utilization of Natural Gas and Means for Their Prevention. By Ralph Arnold and Frederick S. Clapp. 29 pages, 9 by 6 inches. Published by Bureau of Mines, Department of the Interior, Washington, D. C., as "Technical Paper No. 38—Petroleum Technology 6."

A general treatise on the distribution and utilization of natural gas. Information is given on the districts in which natural gas occurs, the methods used in distributing it, and means of eliminating the wastes which have occurred in the past through unscientific methods of handling this valuable natural product.

Practical Mathematics. By Claude Irwin Palmer. 147 pages, 7 by 4¾ inches. 68 illustrations. Published by McGraw-Hill Book Co., 239 West 39th St., New York City. Price 75 cents.

This is the fourth part of a treatise, "Practical Mathematics," and deals with the subjects of trigonometry and logarithms. Like the preceding parts of the series dealing with arithmetic, geometry and algebra (which have already been reviewed in MACHINERY) the present part has been developed to meet the requirements of practical men. Each step is illustrated by problems so that the method of applying mathematical knowledge in the shop is clearly explained.

The Motor and the Dynamo. By James Loring Arnold. 178 pages, 9 by 6 inches. 166 illustrations. Published by the Chemical Publishing Co., Easton, Pa. Price $1.50.

The text is divided into seven chapters and covers the fundamental principles of direct and alternating current electricity and the design and construction of direct and alternating current dynamos and motors. Taken by chapters, the subject matter may be briefly outlined as follows: "Introduction," "Mathematical Principles," "The Dynamo Machine," "Operation and Characteristics of the Direct Current Dynamo," "The Direct Current Motor," "The Alternating Current and Its Measurement," "Alternating Current Machinery."

Practical Mathematics for Technical Students. By Edward L. Bates and Frederick Charlesworth. 513 pages, 4¾ by 7¼ inches. Published by D. Van Nostrand Co., 25 Park Place, New York City. Price $1.50 net.

The work contains an introduction to algebra and fractions, measurements, use of squared paper, operations with fractions, duo-decimals, algebraic operations, geometrical definitions, measurements of angles, ratio and proportion, logarithms, geometry of rectilinear figures and right-angle triangles, mensuration of regular figures, simultaneous simple equations, quadratic and cubic equations, factors, binomial theorem, vectors, trigonometry, rates of increase, differentiation, integration, etc.

Air Compression and Transmission. By H. J. Thorkelson. 207 pages, 9⅝ by 6⅜ inches. 143 illustrations. Published by McGraw-Hill Book Co., 239 West 39th St., New York City. Price $2.00 net.

The work deals with the properties of compressed air, the purposes for which it is used and the machines and equipment for its generation and transmission to different units in the factory. The opening chapters are devoted to a discussion of the fundamental properties of compressed air and the formulas presented in this section are those which appear in most of the standard textbooks on thermodynamics. After this treatment has been covered, a description of different forms of equipment and the purpose for which they are used, is taken up in some detail.

Manual of Wireless Telegraphy and Telephony. By A. F. Collins. 300 pages, 5 by 7¼ inches. 129 illustrations. Published by John Wiley & Sons, New York City. Price $1.50 net.

This work has passed into the third edition. The improvements made in wireless telegraphy during the past decade have necessitated a thorough revision of the book first published in 1906. The alternating-current transformer has largely taken the place of the induction coil, and the auto receptor has practically superseded the coherer receptor. The contents of the work by chapter heads are: "A Simple Wireless Telegraph System," "Elementary Theory," "Apparatus of a Commercial Station," "Apparatus of a Commercial Station" (Continued), "The Aerial Wire System," "Wiring Diagrams for Transmitters," "Wiring Diagrams for Receptors," "The Apparatus in Action," "Adjusting and Operating the Instruments," "Different Makes of Equipment," "Suggestions to Operators," "Wireless Telephony," "Glossary of Wireless Words, Terms and Phrases."

The New Steam Tables, Together With Their Derivation and Application. By C. A. M. Smith and A. G. Warren. 101 pages, 5½ by 8 1/5 inches. Published by D. Van Nostrand Co., 25 Park Place, New York City. Price $1.25 net.

The work is based on the researches of Prof. H. L. Callendar, being calculated originally from Callendar's equations and checked with Mollier's steam tables where possible. The tables comprise "Properties of Saturated Steam on Pressure Base" (Pound Centigrade Units), "Properties of Saturated Steam on Centigrade Temperature Base," "Specific Heats of Superheated Steam at Various Temperatures (Centigrade) and Pressures," "Average Specific Heats of Superheated Steam from Saturation to Tabulated Temperatures (Centigrade) at Various Pressures," "Properties of Saturated Steam on Pressure Base" (Pound-Fahrenheit Units), "Properties of Saturated Steam on Fahrenheit Temperature Base," "Specific Heats of Superheated Steam at Various Temperatures (Fahrenheit) and Pressures," "Average Specific Heats of Superheated Steam from Saturation to Tabulated Temperatures (Fahrenheit) at Various Pressures." A folder is included showing Mollier's chart for total heat and entropy as coordinates.

Safety Valve Rating. By Alfred B. Carhart. 105 pages, 9 by 6¼ inches. 8 illustrations. Published by Press of George H. Ellis Co., Boston, Mass.

This text presents a new method of rating safety valves and is intended as an elementary discussion of the subject. There are really three new rules proposed which have been developed from one another in sequence, and any one of these rules could form a satisfactory basis for an acceptable rule or table. All calculations have been given in detail so that each step will be clear to readers who are interested in this subject. Besides the descrip-

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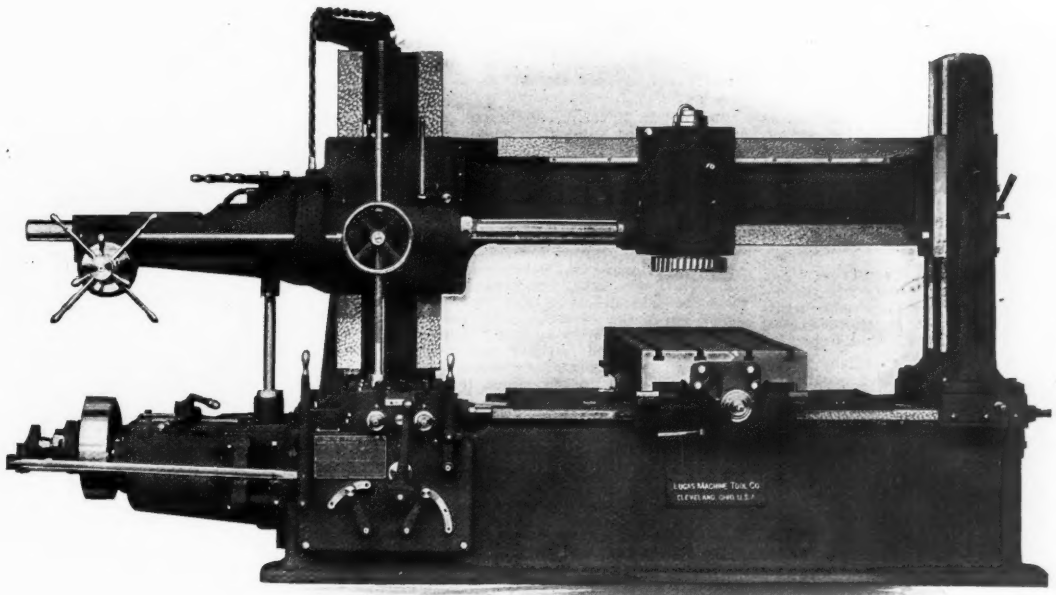

It is so simple that you can see ALL of it ALMOST at a GLANCE and you DON'T HAVE TO LEARN TO RUN IT.

LUCAS MACHINE TOOL CO., NOW AND ALWAYS OF **CLEVELAND, O., U.S.A.**

AGENTS: C. W. Burton, Griffiths & Co., London. Alfred H. Schutte, Cologne, Berlin, Brussels, Paris, Milan, St. Petersburg, Barcelona, Bilbao. Donauwerk Ernst Krause & Co., Vienna, Budapest, Prague. Overall, McCray, Ltd., Sydney, Australia. Andrews & George, Yokohama, Japan. Williams & Wilson, Montreal, Canada.

tions and mathematical derivation of the different rules the following suggestions have been made: (1) Any rule of valve rating should give the valve diameter instead of valve area. (2) Valve lifts should not increase in direct proportion to diameters as this gives too low a lift in small sized valves and too great a lift in large valves. (3) Large valves should lift less than small valves. (4) Any valve should lift less at high pressures and more at low pressures. (5) The calculation of the discharge rating of a safety valve to determine the maximum emergency boiler protection should be taken at a rate greater than that indicated by the nominal working pressure usually assumed.

NEW CATALOGUES AND CIRCULARS

Producers Supply Co., Franklin, Pa. Circular of the "Producers" gas engine built in sizes of 10 to 30 H.P.

Armstrong Cork Co., Pittsburg, Pa. Folder advertising Nonpareil steam pipe covering for steam lines and boilers.

Ohio Valley Pulley Works, Inc., Maysville, Ky. Card advertising the "Limestone" wood split pulleys for all classes of service.

Von Wyck Machine Tool Co., Cincinnati, Ohio. Circular illustrating and describing new sixteen-inch engine lathe with apron geared feed.

Reading Iron Co., Reading, Pa. Bulletin No. 10 on the Ilmer gas engine, an improved engine of the double-cutting, two-stroke cycle type.

Chicago Pneumatic Tool Co., Fisher Bldg., Chicago, Ill. Catalogue No. 42 on the Boyer speed recorder for application to locomotives and cars.

Oswego Tool Co., Oswego, N. Y. Circular of the Oswego-Dickson improved "Stillson" wrench, made in sizes from six inches to forty-eight inches, inclusive.

Electric Controller & Mfg. Co., Cleveland, Ohio. Bulletins Nos. 1032 and 1035 on Type H cast grid resistance and Type B limit stops for direct current motors, respectively.

Phoenix Mfg. Co., Eau Claire, Wis. Circular of the Conradson turret toolpost for use on engine lathes, illustrating tools and applications to typical engine lathe work.

Canton Foundry & Machine Co., Canton, Ohio. Catalogue of conductor pipe and eave trough machinery, paint rolls, drop presses, melting outfits and dies for ceilings, sidings, cornices, etc.

Cling-Surface Co., 1018 Niagara St., Buffalo, N. Y. Booklet on the use of "Cling-Surface" for canvas belts illustrating a number of canvas belting installations where "Cling-Surface" has been used with marked success.

Albany Lubricating Co., 708-710 Washington St., New York City, has begun the publication of a house organ known as "The Bearing." It will be devoted to lubrication in general and the use of Cook's lubricants in particular.

Panama-Pacific International Exposition, San Francisco, Cal. Rules and regulations for the information and guidance of intending participants and bulletin on the official classification of exhibit departments for the information of exhibitors.

Electric Controller & Mfg. Co., Cleveland, Ohio. Bulletins 1000, 1033, 1034 on Dinkey ventilated controllers for direct-current motors, E. C. & M. automatic pressure regulators for direct-current, type U controllers for direct-current motors, respectively.

General Electric Co., Schenectady, N. Y. Bulletins Nos. A4061, A4084, A4102, A4113 on electric arc headlights, centrifugal air compressors, sewing machine motors, oil switches for small capacity industrial application, respectively.

Hess-Bright Mfg. Co., 17 E. Erie Ave., Philadelphia, Pa. Data sheet No. 93, Class V, on pulley mounting for rope drive or hoisting sheave, showing the application of ball bearings; data sheet No. 94, Class IX, on ball-bearing arbor for heavy-duty wood shaper.

Dodge Mfg. Co., Mishawaka, Ind. Pamphlet entitled "Main Engine Drives," illustrating the making of large rope driving wheels and installations of same; also containing numerous testimonial letters from large plants in which the Dodge system has been installed.

Mesta Machine Co., Pittsburg, Pa. Pamphlet on the Mesta blowing engines, illustrating the new Iversen air valve, which requires no valve gear, gives great volumetric and mechanical efficiency, requires no lubrication and operates efficiently up to 100 revolutions per minute.

Bristol Co., Waterbury, Conn. Bulletin No. 169 on counters which automatically count and register revolutions or strokes. These counters are made to count 10,000, 100,000 or 1,000,000, and one style is furnished with set-back by which all numbers can be turned back to zero with one turn of the key.

General Electric Co., Schenectady, N. Y. Bulletin No. A4116 describing isolated and small plant alternating current switchboard panels, both generator and feeder, for three-phase, 25 to 60-cycle circuit. Bulletin No. A4119, devoted to the application of electricity to the operation of packing establishments.

Firth-Sterling Steel Co. (Wheelock, Lovejoy & Co.), 23 Cliff St., New York City. Circulars on Firth-Sterling steel for punches, dies, chipping chisels, twist drills, reamers, counterbores, threading dies, screw drivers, etc.; also pamphlet entitled "The Relation of Tool Steel Prices to Manufacturing Costs."

Stark Rolling Mill Co., Canton, Ohio. Booklet on "Toncan" metal and corrosion. "Toncan" metal is claimed to be far less affected by corrosion than ordinary commercial steel. Many buildings covered with "Toncan" metal are illustrated and other structures are shown in which this metal plays an important part.

E. M. Dart Mfg. Co., Providence, R. I. Folder illustrating and giving dimensions of Dart unions and flanges. These are provided with two bronze seats which prevent corrosion, and with malleable pipe ends and nut, insuring strength and durability. A number of different types of straight, elbow and tee-unions are shown.

Metal Treating and Equipment Co., Inc., 1784 Broadway, New York City. Pamphlet entitled "Protection of Iron and Steel against Corrosion," treating of corrosion, galvanizing, hot galvanizing, sherardizing, electro-galvanizing and describing the "Standard" galvanizing process for which certain advantages are claimed.

National Tube Co., Frick Bldg., Pittsburg, Pa., has issued a book of forty pages on the Matheson joint pipe, showing scenes where it is being installed. Some of the advantages of Matheson joint pipe enumerated are: Reduced weight compared to cast iron, saving in lead used per mile, ability to lay pipe on a vertical curve, etc.

Joseph Dixon Crucible Co., Jersey City, N. J. Booklet entitled "Graphite for the Boiler" recommending the use of fine flake graphite in steam boilers to minimize the time and power lost while cleaning, to increase efficiency of heating surfaces, to reduce fuel consumption, to minimize repairs and to improve the operation of feed pumps, etc.

Rugen-Maschinen-Fundament Co., Ltd., Bismarck-Strasse 97-98, Charlottenburg, Berlin, Germany. Pamphlets on the Rugen machine foundation, consisting of rubber mats placed between the machine and floor. These mats eliminate the necessity of bolts or other fastenings. They also insulate machinery which is often desirable when electrically operated.

General Electric Co., Schenectady, N. Y. Bulletin No. A4110 on cloth pinions for use where the noise of metallic gears is objectionable. Cloth pinions are offered as a substitute for rawhide, paper and other materials for deadening gear sounds. Data are included on the horsepower capacity of pinions, which will be found helpful when ordering them for installations.

H. W. Johns-Manville Co., Madison Ave., & 41st St., New York City. List of J-M asbestos, magnesia and electrical products for roofing and building materials, non-conducting coverings, steam packings, "Vulcabeston," fireproof cements, asbestos fabrics and specialties, asbestos household articles, electrical supplies, cold storage insulation and specialties.

Sleeper & Hartley, Worcester, Mass., designers and builders of automatic machinery. Bulletin No. 252 on plain spring coiling machine; Nos. 254, 260 and 261 on universal coiling machines; No. 264 on spring setting machines; No. 268 on helical cutting and hooking machines; No. 270 on torsion spring machines. These bulletins give illustrations of the machines described and specifications of the product for which each is adapted.

General Electric Co., Schenectady, N. Y. Bulletin No. A4071 on lamp brackets and suspension fixtures for incandescent street lighting; Bulletin No. A4087 on direct current motor starting panels for heavy service; Bulletin No. A4097 on General Electric ventilated railway motors; Bulletin No. A4095 on direct current switchboards; Bulletin No. A4947 on Edison Mazda lamps for railway service.

South Bend Machine Tool Co., South Bend, Ind. Booklet entitled "How to Care for, Erect and Operate a Screw Cutting Engine Lathe," containing practical instructions for the guidance of buyers and users of engine lathes. Directions are given for setting up, leveling and belting lathes, for finding speeds and sizes of tools, preparing work for turning, setting the tool, gearing for thread cutting, turning tapers, use of center rests, cutting speeds, etc.

Tate-Jones & Co., Inc., Empire Bldg., Pittsburg, Pa. Second bulletin of "Blacksmithing and Drop Forging" handbook treating of the hammer, the press, effect of the press compared with the hammer, large heating furnaces, modern tendency in forge shops, the band saw in forge shops, hollow shafts, working temperatures, finishing temperatures, working and finishing colors for steel, necessity for annealing, annealing temperatures, annealing furnaces, alloy steels, etc.

Cleveland Punch & Shear Works Co., Cleveland, Ohio. The "Cleveland" handbook No. 5, showing dimensions of punches and dies for different classes of work, couplings, rivet sets, chisel blanks, flue beading tools, cold chisels, rivet busters, hand rivet sets, drift pins, wrenches, reamers and high-speed drills, hand punches, punching machines, angle shears, bar shears, bending rolls, multiple punch or gate shear, rotary planers, wall radial drills, planers and shapers.

Heine Safety Boiler Co., St. Louis, Mo. Pamphlet on the Heine safety boiler, containing a number of advertisements of well-known manufacturing concerns in whose power plants the Heine safety boilers are installed. The pamphlet also contains advertisements of the Heine superheaters, pointing out important advantages of this type of superheater, such as the close temperature regulation, absence of necessity of flooding, impossibility of danger from excessive superheating, etc.

New Process Gear Corporation, Syracuse, N. Y. Treatise on noiseless gear driving and catalogue of "New Process" gears and pinions. The disturbing effect of gear noises upon the workmen is discussed. Installations are illustrated of machines equipped with rawhide pinions in order to minimize gear noises. The construction of spur and bevel rawhide gears is illustrated. The price list comprises blanks and pinions from one inch face and two inches outside diameter to ten inches face and fifteen inches outside diameter, inclusive.

Hoskins Mfg. Co., 459 Lawton Ave., Detroit, Mich. Bulletin No. 3 on Hoskins thermo-electric pyrometers, treating of temperature measurements, the thermo-electric pyrometer, Hoskins thermo-couples, Hoskins meters, resistance of pyrometer leads, Hoskins cold-end regulation, protecting tubes, permanent pyrometer installations, high resistance thermo-electric pyrometers, applications of thermo-electric pyrometers and calibration of pyrometers. The bulletin is of general interest to all concerned with the heat-treatment of metals and other work requiring exact temperature measurements.

Cincinnati Shaper Co., Cincinnati, Ohio. Catalogue H on traverse shapers, open side shapers and crank planers. The traverse shapers are made with one or two heads and of 18, 22 and 26-inch strokes with even length beds from 8 to 20 feet. The open-side shapers are made to plane 15, 20, 25, 30 and 40 inches width and from 30 inches to 102 inches length. The crank shaper sizes are 17 by 17 by 12 inches and 24 by 24 inches, respectively. The catalogue also shows the Cincinnati heavy duty 32-inch railroad and manufacturing shaper, designed with the view of machining locomotive driving boxes and similar heavy parts.

Jones & Lamson Machine Co., Springfield, Vt. Publication entitled "The Fay Automatic Lathe," describing a machine developed especially for the automatic turning of work held on centers or on centered arbors. The book, which contains 45 pages and is handsomely illustrated, printed and bound, discusses the field for the Fay automatic lathe in the machine shop and deals with some of the problems met with in selecting the proper machines for certain work. It gives a detailed description of the design and construction of the machine, pointing out its advantages and showing examples, illustrated by line engravings, of work that can be done on the machine.

Davis-Bournonville Co., Hudson Terminal Bldg., 30 Church St., New York City. Catalogue of oxy-acetylene welding and cutting apparatus for welding iron, steel, cast iron, aluminum, brass, copper, platinum and other metals, and for cutting iron and steel. The oxy-acetylene flame has a temperature of about 6300 degrees F. and is the hottest of all gas flames. The catalogue illustrates various styles of acetylene generators, both stationary and portable types, and includes diagrams showing the lay out of plants for generating and compressing acetylene and oxygen. The various forms of Davis-Bournonville torches are illustrated; also the mechanical apparatus for guiding cutting torches for cutting steel plates, beams, etc. A number of new machines are shown, including the "radiagraph" and the "holograph."

TRADE NOTES

Electric Specialty Co., Stamford, Conn., successor to the Engineering Electric Mfg. Co., Inc., is a manufacturer of electric motors, both alternating and direct current types, motor generators, dynamos and electrical specialties.

American Blower Co., Detroit, Mich., announces that the Hon. William C. Redfield having been appointed a member of President Wilson's Cabinet, has deemed it advisable to terminate his business connections and has resigned as vice-president and director.

Munning-Loeb Co., Matawan, N. J., announces that it has obtained exclusive rights for the manufacture and sale of the "None-Such" single cylinder and double cylinder, rotating plating barrels covered by a patent of S. D. Catlin, and formerly sold by the firm of Rockhill & Vietor.

Bardons & Oliver, Cleveland, Ohio, manufacturers of turret lathes, have just completed a six-story addition to their factory which will greatly increase their capacity and make it possible to take care of their rapidly increasing business. The new shop contains many unique features and is thoroughly modern in its construction.

Titanium Alloy Mfg. Co., Niagara Falls, N. Y., announces that the sales of its products will hereafter be in charge of the general manager, Mr. Andrew Thompson, with offices at Niagara Falls, N. Y. Mr. A. C. Hawley will represent the company in the Pittsburg district, in the Oliver Bldg., Pittsburg, Pa.

Taft-Peirce Mfg. Co., Woonsocket, R. I., has moved its New York City office from the City Investing Bldg., to the Woolworth Bldg., where one-half the thirty-fourth floor will be occupied. The new offices of seven rooms will provide quarters for the president, vice-president, general manager, treasurer, two sales representatives, etc.

Bridgeport Mechanical Co., Bridgeport, Conn., has been incorporated with a capital of $50,000 to promote American inventions, to do first-class mechanical work and efficiency engineering and to systematize manufacturing, etc. The officers are: L. G. Wagner, president and treasurer; T. B. Lasher, vice-president; W. G. Lohmeyer, secretary.

Niagara Machine & Tool Works, Buffalo, N. Y., is offering $200 in prizes consisting of a first prize of $100; second prize, $40; third and fourth prizes, $20 each, and fifth and sixth prizes, $10 each, for new ideas and methods for sheet metal working. The ideas offered will be submitted to a committee and the names of the prize winners will be published January, 1914.

Taft-Peirce Mfg. Co., Woonsocket, R. I., is building an addition to its factory in the shape of a four-story tower, which will provide an entrance to the new offices on the fourth floor just completed. The tower will be fireproof, having a concrete shaft lined with glazed tile. Fireproof vaults and tool cribs will be provided on the second and third floors.

J. M. Voith Co., Inc., 200 Fifth Avenue, New York City, has been incorporated to sell in the United States and Canada the water wheels, gov-

He Was Particular—

A manufacturer of dental tools found difficulty in getting a spring wire that had just the right temper and resiliency: "It must bend twice at opposite angles and not break. But—it must break clean on the third bend." Such were his exacting specifications.

After much experimenting he "put it up to us" and we suggested Felten & Guilleaume Imported Steel Music Wire.

It solved his problem and for several years now we have had his contract for this wire.

Let us show you what Felten & Guilleaume Imported Steel Music Wire can do for YOU.

Ask for circular No. 3125

Hammacher, Schlemmer & Co.

HARDWARE, TOOLS AND SUPPLIES

New York, since 1848 **4th Avenue and 13th St.**

You Want Accuracy and Endurance, Don't You?

When you buy drills the first cost is worth consideration *only* after you have determined by real use, the actual amount of *work* these drills will do.

Yes! Morse Drills *do* cost more than others, but it's all because they will as surely do *more* than others!

We invite any fair comparative test. We want your orders for Morse Drills only after you are convinced, by just such a trial, that they are most economical in the end. It's a good time to contract!

Tell us your Drill troubles and we'll suggest an economical remedy

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HARDWARE, TOOLS AND SUPPLIES

New York, since 1848 **4th Avenue and 13th St.**

ernors, pulp and paper machinery manufactured by the J. M. Voith Engineering Works of Heidenheim-Brenz, Germany, and St. Poelten, Austria. Mr. F. H. Storrer will be the manager of the company in America.

Kelly Reamer Co., Cleveland, Ohio, announces that the following officers were re-elected at a recent annual meeting of the stockholders: W. E. Kelly, president and general manager; W. L. Calhoon, vice-president; H. J. Maxwell, secretary; O. H. P. Davis, treasurer. The company reports a greatly increased demand for the Kelly adjustable floating reamers, necessitating overtime work during the past four months.

E. B. Van Wagner Mfg. Co., Syracuse, N. Y., manufacturer of finished die castings parts and bearings, has removed its general office to the factory at Fayetteville, N. Y., just outside of Syracuse. A Syracuse office is still maintained by the company in the Union Bldg., but all business is transacted from the main offices at the factory. Mr. H. L. Babcock, formerly of the H. H. Franklin Mfg. Co., is now representing the Van Wagner Mfg. Co. in the Middle West.

Automatic Devices Co., Galesburg, Ill., has been formed by C. F. Hurburgh, E. M. Wharff and R. C. Wharff, who have purchased the good will, material, tools and machinery of the Robson Mfg. Co., of the same city. The new company will manufacture an automatic, spring-operated engine starter for automobiles and gasoline engines known as the "Knutson" starter, being the invention of A. W. Knutson. The company will also continue the Robson Mfg. Co.'s business in emery wheel and grindstone dressers, hose clamp tools and other special tools, machines and devices.

Lumen Bearing Co., Buffalo, N. Y., brass founders, manufacturers of bearings, etc., suffered loss by fire May 11. The fire destroyed the coke and sand sheds and the wood buildings at the rear of the main foundry. The wooden buildings were consumed, but the fire was stopped by the concrete floors and roof of the pattern shop and the fire doors between it and the pattern storage building which closed automatically. No damage was done to patterns or the foundry proper, and the work of replacing the burned portion with fireproof buildings is under way. No interruption to business was caused and all orders are being filled with the usual promptness.

Norton Grinding Co., Worcester, Mass., demonstrated the heaviest roll grinding machine ever built, at its works in Worcester, May 14. The demonstration was witnessed by many machinery builders and engineers who were much interested in the remarkable power and accuracy of the machine. The total weight of the machine is 50 tons, size of grinding wheel 8 by 24 inches and weight of grinding wheel 200 pounds. Five electric motors, one of 40 horsepower, are provided to operate. The demonstration was made on a cast-iron roll not chilled and the accuracy was tested by a straightedge and test indicator which showed that the cylindrical surface was straight and truly round within 0.0005 inch.

Graton & Knight Mfg. Co., Norfolk and Suffolk Sts., Worcester, Mass., manufacturer of leather belting, recently held a salesmen's convention at its main factory which was attended by the company's salesmen from all parts of the country. The convention was devoted to an inspection of the factory, study of methods of manufacture and to the sale and application of the company's products. At the conclusion of the convention a banquet was served, at which more than one hundred officers, salesmen and other employes were present. A feature of this meeting was the presence of Henry C. Graton, founder of the business. The business was founded in 1851 and has grown from a small beginning to one of the largest of its kind in the world.

Hess Steel Castings Co., Witherspoon Bldg., Philadelphia, Pa., states that the ideal metal for casehardening boxes, pots for lead, cyanide and salt hardening baths, containers for molten zinc and die casting metals, etc., is wrought iron. Of all the base metals, wrought iron best withstands high temperatures, frequent heating and cooling with the least deterioration by warping, scaling and cracking. It is, therefore, the best metal for casting into pots and vessels for the purposes mentioned. To successfully cast wrought iron is, however, a foundry task beset by many difficulties. The company has developed the practice of producing wrought iron castings successfully and is making a specialty of castings for casehardening boxes, etc. Other specialties are wrought iron castings of great magnetic permeability for electro-magnetic apparatus.

Russell Mfg. Co., Greenfield, Mass., is a new concern incorporated under the laws of Massachusetts for the manufacture of an improved line of screw-plates, taps, dies and other small tools and machinery. The officers of the company are: Whitman Russell, president; Charles C. Russell, vice-president and treasurer. The directors are Whitman Russell, Charles C. Russell and Lucius D. Potter. The superintendent is H. J. Smith. Charles C. Russell was for many years general manager of the Wiley & Russell Mfg. Co., and Whitman Russell was superintendent. They retired from that company April 1, 1912, when the controlling interest of the Wiley & Russell Mfg. Co. was secured by the Greenfield Tap & Die Corporation. A new factory about 75 by 140 feet will be built at once at Greenfield and the new company will begin producing goods at the earliest possible date.

Van Dorn & Dutton Co., Cleveland, Ohio, has disposed of its portable tool department to a new company which will be known as the Van Dorn Electric Tool Co., with headquarters at Cleveland, Ohio. The officers of the new company are: W. P. Johnston, president and treasurer; H. A. Rock, secretary. The directors are: George D. Barnard, John M. Gannett, H. A. Rock, F. H. Hodell, Frank Schneider and W. P. Johnston. Mr. Johnston, the president, was for over thirty years connected with the George D. Barnard Co., St. Louis, Mo., and was also general manager of the Art Metal Construction Co., of Jamestown, N. Y. Mr. Rock, the secretary, has been for a number of years the general manager of the metal furniture department of the Van Dorn Iron Works, Cleveland, Ohio. The same branch sales offices will be maintained as have heretofore represented the portable tool department of the Van Dorn & Dutton Co. The Van Dorn & Dutton Co., will be devoted entirely to the gear cutting business in the future.

Panama-Pacific International Exposition will be held in San Francisco, Cal., in 1915. It will have an important department of machinery exhibits. The machinery building, having a length of 967.8 feet and a width of 367.8 feet, will be the largest of the exhibit group of fourteen main exhibit buildings. Work on this building was begun early in the year, and it will be in shape to permit the complete installations of exhibits by the opening date, February 20, 1915. Electrical machinery will be located in the machinery building and classed under the general heading of machinery. All parts of the building will be served by adequate crane facilities. Electric current, alternating and direct, gas and water, will be available in all portions of the building. The floor is designed for a load of 200 pounds per square foot, and soil conditions will permit heavy foundations to be readily constructed. No charge will be made for exhibit space. The management urges that all desiring to exhibit machinery at the exhibition make early application for space.

Miscellaneous Advertisements—Situations, Help Wanted, For Sale, etc.

Advertisements in this column, 20 cents a line, seven words to a line. The money should be sent with the order. Answers addressed to our care will be forwarded. Original letters of recommendation should not be enclosed to unknown correspondents.

HARDENING and METAL TREATING.—C. U. SCOTT, Davenport, Iowa.

TEST INDICATORS.—H. A. LOWE, 1374 East 88th St., Cleveland, Ohio.

100 NEW Lathe Chucks. $10 to $20 each, all sizes. LUCAS & SON, Bridgeport, Conn.

WELLES TOOLS are different. Get a catalogue and price list. WELLES CALIPER COMPANY, Milwaukee, Wis.

AGENTS IN EVERY SHOP WANTED to sell my sliding calipers. Liberal commission. ERNST G. SMITH, Columbia, Pa.

FOR SALE.—Pratt & Whitney Turret Lathe; also Rockford heavy four-spindle gang drill CHEAP. Address Box 395, Streator, Ill.

DRAUGHTING AND TRACING. Machines designed. Patent Office Drawings. DURHAM BROTHERS, 1213 Filbert St., Philadelphia.

WANTED.—Experienced crane erectors. Must have had electrical experience and furnish references. THE TOLEDO BRIDGE & CRANE CO., Toledo, Ohio.

AUTOMATIC AND SPECIAL MACHINES designed. Working drawings. Tracings. Special Tools and Fixtures designed. C. W. PITMAN, 3519 Frankford Ave., Philadelphia, Pa.

WE DESIGN mill and factory buildings, engines, boilers, special machinery and cranes. We also do tracing and blue-printing. THE DRAFTING CONCERN, Box 13, Sta. B., Cleveland, O.

WANTED.—FIRST CLASS HAMMERSMAN, able to work from blue print on job work. Steady work and good pay to right man. Address Box 558, care MACHINERY, 49 Lafayette St., New York.

WANTED.—Several First Class Ordnance and Turret Draftsmen. Give fully age, experience, education and references. Address Box 562, care MACHINERY, 49 Lafayette St., New York.

WE HAVE A WELL EQUIPPED SHOP and are in a position to execute promptly orders for light machinery and machine parts. High grade workmanship. GRIMM MFG. CO., Buffalo, N. Y.

WANTED.—FOREMAN who has good executive ability and practical experience in punch and die work for drawing copper tubes. Address Box 561, care MACHINERY, 49 Lafayette St., New York.

FOR SALE.—5,748 STEEL TUBES ⅝" O. D., No. 16 Gauge, 20 inches in length. 5,680 Steel Tubes, ⅝" O. D., No. 16 Gauge, 16 inches in length; all in perfect condition. Address Box 563, care MACHINERY, 49 Lafayette St., New York.

WANTED. — Toolmakers', machinists' attention. Complete and surprising features in our newly issued circular (No. 3), on Boulet's Universal Micrometer Test Indicator. Write to-day to BOULET'S FINE TOOL WORKS, Sebago Lake, Maine.

WANTED.—MACHINIST who is familiar with lathe, planer, shaper and wheel press work. Must also be able to overhaul and set up shop machinery. State salary expected. Address Box 560, care MACHINERY, 49 Lafayette St., New York.

DRAFTSMEN AND MACHINISTS.—American and foreign patents secured promptly; reliable researches made on patentability or validity; twenty years' practice; registered; responsible references. EDWIN GUTHRIE, Corcoran Building, Washington, D. C.

PATENTS.—H. W. T. JENNER, patent attorney and mechanical expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had, and the exact cost. Send for full information. Trade-marks registered.

METAL PATTERN FINISHERS, TOOL AND DIE MAKERS. — Rapid business expansion necessitates employment of few first-class men. Work 57 hours per week. Good location. Furnish references and state hourly wages expected. THE FULTON COMPANY, Knoxville, Tenn.

FOR RENT.—Factory floor space in large or small quantity at Racine, Wisconsin, on tracks of C. M. & St. P. Railway and C. & N. W. Railway. Labor, transportation and power facilities unexcelled. Address for particulars—CARPENTER & ROWLAND, Hotel Racine Bldg., Racine, Wis.

POSITION WANTED.—Technical graduate with shop, testing, designing and sales experience in internal-combustion engine lines; member Gas Power Section A.S.M.E.; desires connection with gas engine concern, or would take teaching position in Engineering School. Address Box 559, care MACHINERY, 49 Lafayette St., New York.

ENGINEERS, SUPERINTENDENTS, designers, draftsmen, production engineers, master mechanics, auditors and other high grade men are invited to file their professional records with us for vacancies now open and in prospect. Only high grade men whose record can stand investigation need apply. THE ENGINEERING AGENCY, Inc.—20th Year—Chicago.

WANTED IMMEDIATELY. — DAY ENGINEER for power plant, steel foundry. Must be able to handle electric machinery and air compressors; also assume responsibility for proper care of boilers and repair of machinery. Married man preferred, must be sober and steady. Give experience and reference in first letter. Address Box 550, care MACHINERY, 49 Lafayette St., New York.

WE ARE EXCEPTIONALLY WELL FITTED to build your light and medium weight machines on contract in reasonable lots. Can store finished material, shipping direct to consumer your single orders or in lots and take the factory end entirely off your hands. Best of shipping facilities. Prompt and efficient service. High class workmanship. Prices right. HOYSRADT & CASE, Kingston, N. Y.

FOR SALE.—One 55 H.P. three-cylinder Westinghouse Gas Engine complete with compressed air tank, pump, generator and batteries of very recent model, used but little and kept in perfect condition. One 20 H. P. two-cylinder No. 5 Nash Gas Engine with small generator and batteries. Can show either one of these engines in working condition and will make an exceptionally low price for cash. PARKS & WOOLSON MACHINE CO., Springfield, Vt.

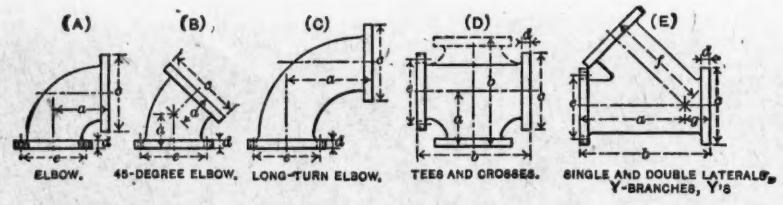
FOR SALE.—No. 3 Owen plain milling machine.
No. 1 Washburn tool grinder.
No. 8 Bardons & Oliver screw machine.
Francis Reed five spindle drill.
King vertical boring mill, 34-inch swing.
Bradford engine lathe, 25 inch, 12 foot bed.
These machines are in perfect condition and were used only three months. Can be seen in operation at our factory. KLENKE PNEUMATIC SUSPENSION COMPANY, 136 West 52d St., New York City.

FOR SALE—ENGINE LATHE OUTFIT—We have for sale an up-to-date set of Tracings, Blue Prints, Patterns, Jigs, Templets and Gauges and Special Tools for a 14-inch Engine Lathe. Also have four 14-inch Lathes in process of construction, which complete outfit we offer for sale. This lathe outfit would be a splendid filler for any machine shop wanting a new line of machinery to build. For further particulars write VALLEY MACHINE COMPANY, Parkersburg, W. Va.

ONE OF THE LARGEST and most progressive tool and supply houses in New York City is desirous of disposing of their business; stock on hand, capital stock and good will, having a satisfactory lease in a convenient section of the city. Satisfactory reasons given for desire to sell. Business is now a growing one and can do 50 per cent. more business without increasing the overhead, owing to excellent organization. Purchasers only need apply, no agent. Address X. Y. Z., Box 556, care MACHINERY, 49 Lafayette St., New York.

WANTED. — Agents, machinists, toolmakers, draftsmen, attention! New and revised edition Saunders' "Handy Book of Practical Mechanics" now ready. Machinists say, "Can't get along without it." Best in the land. Shop kinks, secrets from note books, rules, formulas, most complete reference tables, tough problems figured by simple arithmetic, valuable information condensed in pocket size. Price post-paid $1.00 cloth; $1.25, leather with flap. Agents make big profits. Send for list of books. E. H. SAUNDERS, 216 Purchase St., Boston, Mass.

STANDARD WEIGHT U. S. STANDARD FLANGED FITTINGS—II



Type of Fitting	1-inch. Diam. Bolts, 7/16. No. Holes 4; Diam., 5/16					
	a	b	c	d	e	f
A	3½	..	4	7/16	3	..
B	2	..	4	7/16	3	..
C	5½	..	4	7/16	3	..
D	3½	7	4	7/16	3	..
E	6†	8	4	7/16	3	6

Type	1¼-inch. Diam. Bolts, 7/16. No. Holes, 4; Diam., 5/16					
	a	b	c	d	e	f
A	3¾	..	4½	½	3⅝	..
B	2	..	4½	½	3⅝	..
C	6	..	4½	½	3⅝	..
D	3¾	7½	4½	½	3⅝	..
E	6½†	8½	4½	½	3⅝	6½

Type	1½-inch. Diam. Bolts, ½. No. Holes, 4; Diam., ⅝					
	a	b	c	d	e	f
A	4	..	5	9/16	3¾	..
B	2¼	..	5	9/16	3¾	..
C	6½	..	5	9/16	3¾	..
D	4	8	5	9/16	3¾	..
E	6¾†	9½	5	9/16	3¾	6½

Type	2-inch. Diam. Bolts, ⅝. No. Holes, 4; Diam., ¾					
	a	b	c	d	e	f
A	4½	..	6	⅝	4½	..
B	2½	..	6	⅝	4½	..
C	7	..	6	⅝	4½	..
D	4½	9	6	⅝	4½	..
E	8†	10½	6	⅝	4½	8

Type of Fitting	2½-inch. Diam. Bolts, ⅝. No. Holes, 4; Diam., ¾					
	a	b	c	d	e	f
A	5	..	7	11/16	5½	..
B	2½	..	7	11/16	5½	..
C	7½	..	7	11/16	5½	..
D	5	10	7	11/16	5½	..
E	9½†	12	7	11/16	5½	9½

Type	3-inch. Diam. Bolts, ⅞. No. Holes, 4; Diam., ¾					
	a	b	c	d	e	f
A	5½	..	7½	¾	6	..
B	3	..	7½	¾	6	..
C	8	..	7½	¾	6	..
D	5½	11	7½	¾	6	..
E	10†	13	7½	¾	6	10

Type	3½-inch. Diam. Bolts, ⅞. No. Holes, 4; Diam., ¾					
	a	b	c	d	e	f
A	6	..	8½	13/16	7	..
B	3½	..	8½	13/16	7	..
C	9	..	8½	13/16	7	..
D	6	12	8½	13/16	7	..
E	11½†	14½	8½	13/16	7	11½

Type	4-inch. Diam. Bolts, ⅞. No. Holes, 8; Diam., ¾					
	a	b	c	d	e	f
A	6½	..	9	15/16	7½	..
B	4	..	9	15/16	7½	..
C	10	..	9	15/16	7½	..
D	6½	13	9	15/16	7½	..
E	12†	15	9	15/16	7½	12

Sign (†) indicates center-to-face dimensions of run on laterals, or double laterals, each way. Dimension g (see illustration E) is also the center-to-face dimension of a Y on the short end. All other dimensions on Y's are the same as for elbows of the same size. A reducing Y carries same dimensions as a straight size Y of the size of the largest opening in the fitting in question.

1912 U. S. STANDARD FLANGED FITTINGS AND FLANGES—I

EXPLANATORY NOTES FOR "THE 1912 U. S. STANDARD"

Adopted by a Committee of the National Association of Master Steam and Hot Water Fitters and the American Society of Mechanical Engineers

Schedule of Standard Weight and Extra-Heavy Flanged Fittings.

1. Standard or extra-heavy reducing elbows have same dimensions from center-to-face as regular elbows of largest straight size.

2. Standard or extra-heavy tees, crosses and laterals, reducing on run, have the same dimensions face-to-face as largest straight size.

3. If flanged fittings are made for lower working pressures than 125 pounds, they shall conform in all dimensions, except thickness of shell, to this standard, and shall have the guaranteed working pressure cast on each fitting. Flanges for these fittings must be standard dimensions.

4. Where long-turn fittings are specified, it has reference only to elbows, which are made in two center-to-face dimensions, to be known as "elbows" and "long-turn elbows," the latter being used only when so specified.

5. All standard weight fittings must be guaranteed for 125 pounds working pressure and extra-heavy fittings for 250 pounds pressure, and each fitting must have some mark cast on it indicating the maker and guaranteed working steam pressure.

6. All extra-heavy fittings and flanges to have a raised surface 1/16 inch high inside of bolt holes for gasket.

Standard weight fittings and flanges to be plain faced.

Bolts to be ⅛ inch smaller in diameter than bolt holes.

Bolt holes should straddle center lines.

7. Size of all fittings scheduled indicates inside diameter of ports. For outside diameter pipe, use corresponding size of inside diameter fittings.

8. The face-to-face dimension of a reducer, either straight or eccentric, shall be equal to the diameter of the larger flange.

9. Square-head bolts with hexagonal nuts are recommended.

10. Twin ells, double-branch ells, side-outlet ells, side-outlet tees and four-way tees, whether straight sizes or reducing, have the same dimensions center-to-face and face-to-face as regular ells and tees.

11. Bull-head tees or tees increasing on outlet, shall have the same center-to-face and face-to-face dimensions as straight fitting of the size of the outlet.

12. Up to and including the 4-inch size, center-to-face and face-to-face dimensions of reducing fittings shall be the same as that of a straight fitting of the larger opening.

Steel flanges, fittings and valves are recommended for superheated steam.

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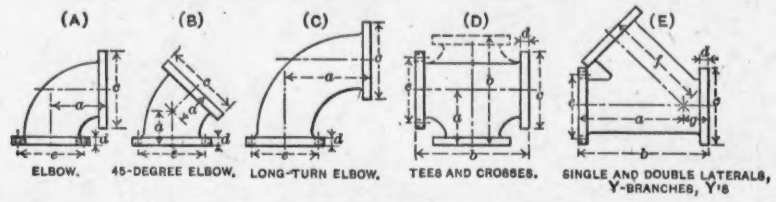
Supplement to MACHINE

Tables for Article in this number entitled "The 1912 U. S. St

STANDARD WEIGHT U. S. STANDARD FLANGED FITTINGS—III



Type of Fitting	4½-inch Diam. Bolts, ¾. No. Holes, 8; Diam., ⅞					
	a	b	c	d	e	f
A	7	..	9½	1 5/16	7½	..
B	4½	..	9½	1 5/16	7½	..
C	11	..	9½	1 5/16	7½	..
D	7	14	9½	1 5/16	7½	..
E	12½	15½	9½	1 5/16	7½	11¾*

* For outlets 4 inches and under. For 4½-inch outlets f = 12¼ inches.

Type of Fitting	8-inch Diam. Bolts, ¾. No. Holes, 8; Diam., ⅞					
	a	b	c	d	e	f
A	9	..	13½	1½	11½	..
B	6	..	13½	1½	11½	..
C	16	..	13½	1½	11½	..
D	9	18	13½	1½	11½	..
E	17½	22	13½	1½	11½	14⅜*

* For outlets 4 inches and under. For 4½- to 8-inch outlets f = 17½ inches.

Type	5-inch Diam. Bolts, ¾. No. Holes, 8; Diam., ⅞					
	a	b	c	d	e	f
A	7½	..	10	1 5/16	8½	..
B	4½	..	10	1 5/16	8½	..
C	12	..	10	1 5/16	8½	..
D	7½	15	10	1 5/16	8½	..
E	13½	17	10	1 5/16	8½	12¼*

* For outlets 4 inches and under. For 4½- and 5-inch outlets f = 13½ inches.

Type	9-inch Diam. Bolts, ¾. No. Holes, 12; Diam., ⅞					
	a	b	c	d	e	f
A	10	..	15	1½	13½	..
B	6½	..	15	1½	13½	..
C	18	..	15	1½	13½	..
D	10	20	15	1½	13½	..
E	19½	24	15	1½	13½	17⅞*

* For outlets 8 inches and under. For 9-inch outlets f = 19½ inches.

Type	6-inch Diam. Bolts, ¾. No. Holes, 6; Diam., ⅞					
	a	b	c	d	e	f
A	8	..	11	1	9½	..
B	5	..	11	1	9½	..
C	13	..	11	1	9½	..
D	8	16	11	1	9½	..
E	14½	18	11	1	9½	13*

* For outlets 4 inches and under. For 4½- to 6-inch outlets f = 14½ inches.

Type	10-inch Diam. Bolts, ⅞. No. Holes, 12; Diam., 1					
	a	b	c	d	e	f
A	11	..	16	1 3/16	14½	..
B	7	..	16	1 3/16	14½	..
C	20	..	16	1 3/16	14½	..
D	11	22	16	1 3/16	14½	..
E	20½	25½	16	1 3/16	14½	18⅝*

* For outlets 8 inches and under. For 9- and 10-inch outlets f = 20½ inches.

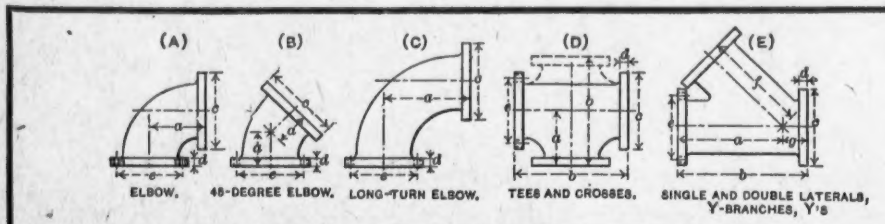
Type	7-inch Diam. Bolts, ¾. No. Holes, 8. Diam., ⅞					
	a	b	c	d	e	f
A	8½	..	12½	1 1/16	10½	..
B	5½	..	12½	1 1/16	10½	..
C	14½	..	12½	1 1/16	10½	..
D	8½	17	12½	1 1/16	10½	..
E	16½	20½	12½	1 1/16	10½	13¼*

* For outlets 4 inches and under. For 4½- to 7-inch outlets f = 16½ inches.

Type	12-inch Diam. Bolts, ⅞. No. Holes, 12; Diam., 1					
	a	b	c	d	e	f
A	12	..	19	1½	17	..
B	7½	..	19	1½	17	..
C	22	..	19	1½	17	..
D	12	24	19	1½	17	..
E	24½	30	19	1½	17	20*

* For outlets 8 inches and under. For 9- to 12-inch outlets f = 24½ inches.

STANDARD WEIGHT U. S. STANDARD FLANGED FITTINGS—IV



Type of Fitting	14-inch Diam. Bolts, 1. No. Holes, 12; Diam., 1⅛					
	a	b	c	d	e	f
A	14	..	21	1⅛	18¾	..
B	7½	..	21	1⅛	18¾	..
C	24	..	21	1⅛	18¾	..
D	14	28	21	1⅛	18¾	..
E	27	33	21	1⅛	18¾	21½*

* For outlets 8 inches and under. For 9- to 14-inch outlets f = 27 inches.

Type of Fitting	20-inch Diam. Bolts, 1⅛. No. Holes, 20; Diam., 1¼					
	a	b	c	d	e	f
A	18	..	27½	1 1/16	25	..
B	9½	..	27½	1 1/16	25	..
C	32	..	27½	1 1/16	25	..
D	18	36	27½	1 1/16	25	..
E	35	43	27½	1 1/16	25	25½*

* For outlets 8 inches and under. For 9- to 20-inch outlets f = 35 inches.

Type	15-inch Diam. Bolts, 1. No. Holes, 16; Diam., 1⅛					
	a	b	c	d	e	f
A	14½	..	22½	1⅛	20	..
B	8	..	22½	1⅛	20	..
C	26	..	22½	1⅛	20	..
D	14½	29	22½	1⅛	20	..
E	28½	34½	22½	1⅛	20	22⅛*

* For outlets 8 inches and under. For 9- to 15-inch outlets f = 28¼ inches.

Type	22-inch Diam. Bolts, 1⅛. No. Holes, 20; Diam., 1¼					
	a	b	c	d	e	f
A	20	..	29½	1 1/16	27½	..
B	10	..	29½	1 1/16	27½	..
C	34	..	29½	1 1/16	27½	..
D	20	40	29½	1 1/16	27½	..
E	37½	46	29½	1 1/16	27½	27⅛*

* For outlets 8 inches and under. For 9- to 22-inch outlets f = 37½ inches.

Type	16-inch Diam. Bolts, 1. No. Holes, 16; Diam., 1⅛					
	a	b	c	d	e	f
A	15	..	23½	1 7/16	21¼	..
B	8	..	23½	1 7/16	21¼	..
C	28	..	23½	1 7/16	21¼	..
D	15	30	23½	1 7/16	21¼	..
E	30	36½	23½	1 7/16	21¼	22⅞*

* For outlets 8 inches and under. For 9- to 16-inch outlets f = 30 inches.

Type	24-inch Diam. Bolts, 1⅛. No. Holes, 20; Diam., 1¼					
	a	b	c	d	e	f
A	22	..	32	1⅞	29½	..
B	11	..	32	1⅞	29½	..
C	36	..	32	1⅞	29½	..
D	22	44	32	1⅞	29½	..
E	40½	49½	32	1⅞	29½	28½*

* For outlets 8 inches and under. For 9- to 24-inch outlets f = 40½ inches.

Type	18-inch Diam. Bolts, 1¼. No. Holes, 16; Diam., 1¼					
	a	b	c	d	e	f
A	16½	..	25	1 9/16	22⅝	..
B	8½	..	25	1 9/16	22⅝	..
C	30	..	25	1 9/16	22⅝	..
D	16½	33	25	1 9/16	22⅝	..
E	32	39	25	1 9/16	22⅝	24½*

* For outlets 8 inches and under. For 9- to 18-inch outlets f = 32 inches.

Type	26-inch Diam. Bolts, 1¼. No. Holes, 24; Diam., 1⅜					
	a	b	c	d	e	f
A	23	..	34½	2	31⅝	..
B	13	..	34½	2	31⅝	..
C	39	..	34½	2	31⅝	..
D	23	46	34½	2	31⅝	..
E	43½	53	34½	2	31⅝	30⅝*

* For outlets 8 inches and under. For 9- to 26-inch outlets f = 43½ inches.